AN INVESTIGATION INTO THE TOPIC SPECIFIC PEDAGOGICAL CONTENT KNOWLEDGE OF BOTSWANA SOCIAL STUDIES TEACHERS: THE CASE OF 'WATER RESOURCES AND THEIR MANAGEMENT'.

BY

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Abstract

The effective teaching of water resource management is critically important to the future sustainability of Botswana, considering that water resources are a shared and scarce resource, unevenly distributed over time and space. Preliminary research (Mosothwane, 2002; Mogotsi, 2007; Ketlhoilwe, 2003/7) suggests that teachers in Botswana struggle to select suitable teaching strategies for Environmental Education (EE)-oriented topics. For this reason, the introduction of Environmental Education (EE) into the Social Studies curriculum could potentially pose a challenge for Batswana teachers to construct and use Pedagogic Content Knowledge (PCK) to teach the topic of 'Water Resources and their management' effectively. Teachers would need to develop a nuanced understanding of EE core concepts to enable them to use appropriate pedagogic methods that promote students' sustainable approaches to environmental management of resources. Environmental education means much more than environmental awareness; it also encompasses the understanding of issues, concern for the environment and a commitment to the wise and sustainable use of resources. This implies a need to link subject knowledge to an appropriate pedagogic approach. Research has established that there exists a relationship between teachers' knowledge of the topic to be taught, their beliefs and their ability to transform content knowledge into a form that is appropriate for teaching. My study, therefore, explores teachers' beliefs about teaching, their environmental worldview and their understanding of EE teaching. I assess their content knowledge on the topic of Water Resources and their Management in Botswana, establish the extent to which they are able to portray topic-specific PCK, and use this knowledge to make appropriate pedagogic choices. I analyse the extent to which their beliefs and understanding of teaching, EE and their content knowledge enable them to approach the topic, Water Resources and their Management in Botswana for effective teaching.

The theoretical framework of the study relies on Shulman's knowledge bases for teaching and Palmer's components for teaching and learning in EE, that is, *in*, *about* and *for* the environment. These were instrumental in developing the data collection tools and the analysis of the data. I used a small selection of participants - Social Studies teachers in Botswana - for data collection

purposes rather than a huge survey. The data collection was done through questionnaires, belief tests, Content Representations (CoRes) and lesson planning. Data analysis relied on Shulman's knowledge bases for teaching and Palmer's components for teaching and learning in EE, that is, *in*, *about* and *for* the environment, formed the base of my theoretical framework.

The findings of my study indicated that the teachers' understanding of what it means to teach effectively foregrounds the role of providing care and backgrounds to the mediation of knowledge. While teachers professed concern for the environment, these concerns were not translated into learning tasks that might develop such concerns, awareness and commitment to environmental sustainability. Although teachers were well able to describe students' prior knowledge, they struggled to articulate how the topic fitted into the curriculum, what constituted appropriate representations of the key issues and which teaching strategies would be most appropriate. My findings further showed that, although the teachers possessed knowledge about water and its use, abuse and management in the country, they did not design lessons that provided opportunities for links between students' experiences in their communities. Instead, the lessons developed provided a variety of generic teaching strategies that were not EE-specific. Their selection was unjustified, lacking Pedagogical Content Knowledge (PCK). The proposed teaching strategies showed no evidence of transformation of the content-specific to EE, did not take into account the students' prior knowledge and were also not closely connected to the goals of EE for motivating students to adopt sustainable lifestyles.

The implications of the findings of this study suggest that there is a gap between EE policy intentions in Botswana and the implementation of EE in secondary schools. Although teachers appear to be well informed about the content knowledge of water resources and their management, they are not yet able to translate their content knowledge into constructing topic-specific PCK. My study suggests that teachers are not yet rising to the challenge of developing a subtle understanding of EE core concepts for an implementation that promotes activism to prompt changes for sustainable living. The study, therefore, proposes an ideal framework for PCK in EE to enable effective teaching of EE-oriented topics. The model

incorporates the categories of teacher professional knowledge bases, Topic Specific Pedagogical Content Knowledge and beliefs influencing classroom practice. The model also takes into consideration the national goals of EE, as well as the components of teaching and learning of EE, that is: *in*, *about* and *for* the environment.

Declaration

I declare that this thesis is my own unaided work. It is being submitted for the degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. I have not been submitted before for any degree or examination in any other university.

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(Signature of candidate)

____ day of _____ 2015

Dedication

I dedicate this work to;

My loving husband Naani: for your constant motivation and support. You believed in me even when I was despairing. Thank you for being 'there' for the kids when I was not.

My children, Nlisi and Bokani: I'm proud of you for understanding when mum spent long hours at the computer doing her 'homework' and travelling to school. May this achievement motivate you to work harder and achieve your best.

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List of acronyms

AKASP	Awareness Knowledge Attitudes Skills Participation
CK	Content Knowledge
CoRe	Content Representation
CoRes	Content Representations
EE	Environmental education
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
IUCN	The International Union for Conservation of Nature
JC	Junior Certificate
MoESD	Ministry of Education and Skills Development
NWMP	National Water Master Plan
Pap-eRs	Pedagogical and Professional Experience Repertoires
PCK	Pedagogical Content Knowledge
RNPE	Revised National Policy on Education
SMK	Subject Matter Knowledge
TPKB	Teacher Professional Knowledge Bases
TSPCK	Topic Specific Pedagogical Content Knowledge
TSPK	Topic Specific Professional Knowledge
TT&D	Teacher Training and Development
UNESCO	United Nations Scientific and Cultural Organization
WCED	United Nations World Commission on Education and Development
WESSA	Wildlife and Environment Society of South Africa
WR&M	Water Resources and their Management
WSOE	Wits School of Education
WUC	Water Utilities Corporation

CHAPTER 1: CONTEXT OF THE STUDY AND RESEARCH QUESTIONS

1.0. Introduction

The chapter provides a brief background to the study, its purpose and the rationale for its initiation. It concludes with a description of the research questions and the structure of the thesis chapters. Here the goals of EE and the challenges to its implementation are highlighted.

Botswana has emerged from being one of the world's poorest countries to having one of the fastest growing economies (Botswana Government, 2007). This phenomenal economic growth has been possible through the country's use of her natural resources (especially mineral resources like diamonds, coal and copper/nickel), tourism and openness to foreign investment and trade. However, there is an increasing strain on the environment, and especially the water resources, owing to the current rate of population growth and rapidly changing lifestyles, characterised by urbanization, and the consequent higher per capita consumption of resources (Botswana Government, 2007). Botswana, therefore, faces major environmental and developmental challenges such as growing pressure on water resources, overgrazing and thus destruction of pastures, water depletion, decline in wildlife numbers, climate change, overuse or exploitation of some veld products, and pollution of air, water, soil and vegetation resources (Botswana Government, 1997; Keatimilwe & Mpotokwane, 2011). In particular, there is growing pressure on water resources, resulting from the increasing population, development and urbanisation.

In Botswana, rainfall is very low and unreliable, ranging between an annual average of 250mm and 650mm. This makes Botswana third among the most water-scarce countries in Southern Africa, after South Africa and Namibia (Toteng, 2008). There are few water sources, most of which are subject to high evaporation rates and resulting in high salinity. The combination of water scarcity or water stress and land degradation is likely to negatively affect Botswana's GDP, poverty, health and food security (Aniku & Segopolo, 2011).

The country's economic growth will not be sustainable unless the people of Botswana take care of their environment. The introduction of Environmental Education (EE) in the Botswana school curriculum in 1994 aimed to promote awareness of the escalating environmental problems in the country, and to encourage students to adopt a more sustainable lifestyle. This was formalised as recommendation number 44 of the Revised National Policy on Education (RNPE) of 1994 (Botswana Government, 1994). Since its introduction, there have been few evaluations of the implementation process, especially in the Junior Secondary Schools. Very little research has been done nationally on teacher content knowledge and the teaching of 'water resources and their management'; hence a knowledge gap exists in the teaching of this crucial topic in the EE curriculum. This study seeks to address this gap.

1.1. Environmental Education in Botswana

1.1.1. Goals and aims of Environmental Education in Botswana

The aim of EE in Botswana is to develop a society that is conscious of and concerned about the environment and its management, in order to build a society that has knowledge, skills, motivation and commitment to the environment (Botswana Government, 1999, p. 2). The Report of the National Commission on Education of 1993 emphasised the importance of sensitising the nation to understanding, preventing and helping solve environmental problems. The national goals of EE are in line with the 1996 National Environmental Education strategy and action plan, as well as the UNESCO objectives of EE of 1977. The incorporation of Environmental Education (EE) into the Botswana curriculum was a strategy to promote the following areas:

- ***Awareness*** - Provide every student with the opportunity to develop environmental awareness, acquire knowledge and understanding of the environment, and appreciate the need for sustainable utilisation of Botswana's natural resources.

- ***Knowledge*** - Provide every student with the opportunity to acquire knowledge and understanding of the environment, interrelationship and interdependence with it and the need for sustainable utilisation of Botswana's natural resources.
- ***Attitudes*** - Develop desirable attitudes and behavioural patterns in interacting with the environment in a manner that is protective, preserving and nurturing.
- ***Skills*** - Develop critical problem-solving ability, individual initiative and interpersonal and inquiry skills to make informed decisions when dealing with environmental issues. This can be achieved by examining personal and societal attitudes and values relating to the environment, as well as identifying alternative approaches to the use and management of the environment.
- ***Participation*** - Willingness to work towards resolving environmental problems, and actively participating in the care and conservation of the environment. (Botswana Government, 1999; Botswana Government, 1994).

These goals of EE are to be integrated into the national curriculum across all subjects, but Social Studies has a particular role to play as the topics (including Water Resources and their Management) are included in its curriculum.

1.1.2. Environmental Education in the Junior Secondary Social Studies curriculum

Social Studies, as a subject in the curriculum in Botswana, can play an important role in preparing students to be environmentally aware citizens, who can make considered decisions and participate positively in the sustainable use of the environment. Space has been created for the inclusion of topics related to EE in the Junior Secondary Social Studies syllabus. Through the study of these topics, it is hoped that students' understanding of the environment will be enhanced, and their interrelationship and interdependence with it will improve. The Social Studies syllabus intends to develop in students the capacity for the sustainable use of resources and encourages conservation at home, at school and in communities, as well as promoting student action and participation in protecting the environment (Botswana Government, 2009,

p. 3). The policies associated with the teaching of Social Studies promote student-centred teaching in which the student takes an active part in the learning process. Approaches such as inquiry, group work, debates and presentations are preferred over chalk and talk methods of instruction in Social Studies (Botswana Government, 2009). The Junior Certificate Social Studies syllabus is organised into six broad units, namely: Map reading and research skills; Environment and humanity; Social and cultural environments; History and foreign relations; Civics and Economic Development (Botswana Government, 2009).

Environment and humanity are aimed at giving "students a deeper understanding of Botswana's physical environment and that of the world around them." It hopes to "… instil in them an appreciation of the interplay between humanity and the environment and the need for the sustainable utilisation of natural resources" (Botswana Government, 2009, p. ii). Both the policy and the syllabus recommend that students, in their development of environmental consciousness and concern, should be allowed to "acquire a global environmental perspective through local and regional environments, and through the use of a variety of educational approaches that encourage appreciation and empathy with the environment" (Botswana Government, 1999, p. ii). Despite this recommendation, teachers are faced with the challenge of developing a sophisticated understanding of EE core concepts for an implementation that instigates lifestyle changes.

1.2. Concerns about the implementation of EE in the Junior Secondary School Social Studies syllabus

Although one of the goals of Social Studies is to ensure that students have acquired desirable attitudes in interacting with the environment for the sustainability of the natural resources, research indicates that this goal is not being realised. A review of the implementation of EE by Ketlhoilwe (2003) revealed that very little environmental education activity is actually taking place in most of the schools in Botswana, and that there is still uncertainty as to how the approaches advocated by EE should be adopted. Although the policy guidelines and aims of EE seem to promote activism towards prompting changes to sustainable living, there seems to be

a gap between policy intentions and what actually happens in the schools. Issues identified in the existing research into the implementation of EE in Botswana include the following:

- **Absence of a monitoring programme for EE** - Unlike other contemporary issues, EE does not have proper coordination and monitoring tools in schools. Presently "the implementation programme for EE is 'loose' and subject to neglect by both educators and supervisors" (Ketlhoilwe, 2003, p. 79). If this tendency continues, EE may well become non-existent in the near future.
- **Lack of resources and facilities -** There is lack of access to information, as well as a lack of resources such as textbooks, pamphlets, worksheets and teacher's guides which could be used to support the teaching and learning of EE effectively and deliver EE awareness messages (Mosothwane, 2002; Ketlhoilwe, 2003). The possibility could also be that the teachers do not actively seek out the resources that are available to them.
- **Insufficient in-service training in environmental education** - Many teachers in schools had little exposure to environmental education during their teacher training at colleges or at university, hence the need for in-service teacher education in environmental education. EE is not well established within the teacher education structures in Botswana yet, so teachers lack the required knowledge on the infusion approach. Consequently, the impact of EE is not reflected in pupils' knowledge, attitudes and practices (Ajiboye & Silo, 2008; Ketlhoilwe, 2007).
- **Attitudes and commitment of teachers -** It appears that environmental education is treated as an extra burden; teachers are not willing to concentrate on it and some also feel it is not necessary to teach it at secondary school level (Ketlhoilwe, 2003, p. 78).
- **Policy Issues -** Although teachers seem aware of the education policy, there is lack of understanding of how environmental education should be implemented, and, thus, a lack of understanding of EE (Ketlhoilwe, 2003; Mosothwane, 2002). Others know what the policy requirements are, but are not actually implementing environmental education (Ketlhoilwe, 2003, p. 80).

Furthermore, the policy of national goals did not embrace the entire field of EE since social justice issues which are representative of the adopted sustainable development appear to have been left out (Ketlhoilwe, 2003/2007).

- **Lack of subject matter knowledge (SMK) on certain EE topics** - Some teachers noted that environmental education concepts are difficult to interpret (Mosothwane, 2002; Mogotsi, 2007; Ketlhoilwe, 2003/7), hence difficult to teach. Teachers' understanding of subject matter creates logical conditions upon which the choice of suitable instructional methods rests (Tal & Argaman, 2005; Morrow, 2007; Shulman, 1986). This, therefore, prompts more inquiry and debates on the extent to which teachers' understanding of concepts enables them to teach EE in a manner that prompts lifestyle changes.
- **The inclusion of Sustainability/Sustainable Development into the EE curriculum** - Sustainability involves "long-term maintenance of wellbeing in environmental, economic as well as social dimensions; it is the ability to meet the needs of the present without compromising that of future generations to meet their own" (WCED, 1987). Conservation is described as the "preservation, protection, or restoration of the natural environment, natural ecosystems, vegetation, and wildlife" while sustainable use refers to "… improving the quality of human life while living within the carrying capacity of supporting eco-systems" (Fien, 1993, p. 193). EE has "gradually shifted from conservation-protection discourses in environmental education to sustainability discourse which is rapidly becoming a dominant discourse shaping the field" (Ketlhoilwe, 2007, p. 314) internationally. In Botswana policy statements and syllabi, there is conceptual confusion that is caused by the simultaneous use of the different discourses of conservation and sustainable use in EE (Ketlhoilwe, 2007). It is not clear if both concepts should be promoted during instruction or if one supersedes the other. This confusion at policy level has implications for how teachers understand the concepts and thus affects the way teachers deliver in their classrooms. It is therefore important to differentiate between these two concepts to resolve any contradictions that may arise in the understanding of EE, conservation and sustainable use.

There seems to be a gap between policy intentions (intended curriculum) and the enacted curriculum, and also between the what, how and why teachers should teach EE and what actually happens. This study addresses the need for a deeper inquiry into the basis of the gap, by considering the beliefs of Social Science teachers (about the nature of teaching about the environment), their understanding of EE and their knowledge of the topic identified and how to teach it.

1.3. Statement of the problem

The teaching of environment education does happen but it seems ineffective (Ketlhoilwe, 2003/7; Ajiboye & Silo, 2008). Teachers are faced with the challenging task of selecting suitable teaching strategies that are appropriate to the content knowledge to be learnt, and also meeting the needs of students. Some of the issues and concerns identified in the implementation of EE in Social Studies point to a problem with the teachers' limited levels of content knowledge on certain EE topics (Mosothwane, 2002; Mogotsi, 2007; Ketlhoilwe, 2003/7). Effective teaching requires a good topic content knowledge and a developed pedagogical content knowledge (PCK). A good content knowledge implies that the teacher understands the content sufficiently to make it easily accessible and understandable to students (Morrow, 2007). PCK is the knowledge that includes knowing what teaching approach fits the content and also knowing how the content can be arranged and presented for effective teaching (Shulman, 1986).

PCK is different from the knowledge shared by teachers across disciplines because it focuses on the "representation and formulation of concepts, pedagogical techniques, and knowledge of what makes concepts difficult or easy to learn, knowledge of students' prior knowledge and theories of epistemology" (Shulman, 1986, p. 10). It includes knowing teaching strategies that integrate "appropriate conceptual representations, to address student difficulties and misconceptions and foster meaningful understanding" (Shulman, 1986, p. 10) and the teachers' adequate subject knowledge (Darling–Hammond & Baratz–Snowden, 2005; Bransford et al, 2000). PCK is argued to be topic-specific (e.g. Reise & Reinhold, 2009; Park et al. 2011; Tepner

& Witner, 2011). Topic Specific PCK is regarded as "the understanding that provides the needed knowledge for Subject Matter Knowledge (SMK) transformation in a particular topic" and "… the conceptualization of Topic Specific PCK is premised on the understanding that transformation of SMK is one of the key elements in the establishment of PCK" (Mavhunga & Rollick 2011, p. 2). Therefore, if teaching requires transformation of comprehension, "'then transformation needs to happen for each topic taught" and that "if PCK is associated with the benefit of transforming comprehension, then the benefit of transformation at a topic level is associated with PCK for that specific topic" (Mavhunga & Rollick 2011, p. 2).

The limited levels of content knowledge and PCK amongst teachers, especially in the topics that are related to the environment, seem to result in the ineffective teaching of EE in Social Studies (Mosothwane, 2002). However, what is not yet known is the extent to which teachers' beliefs may influence their ability to construct PCK, despite adequate levels of content knowledge. I draw on literature about PCK, and the links PCK has to belief systems and teachers' understandings of content knowledge as a lens to explore teachers' approaches to the teaching of Water Resources and their Management.

1.4. Purpose of Research

Teachers are expected to integrate EE into their teaching and to successfully plan and carry out projects in Junior Secondary schools nationally, using pedagogic methods that promote environmental awareness and understanding, and reinforce students' commitment to sustainability. The purpose of this research is therefore to explore Social Studies teachers' environmental worldviews, their beliefs about teaching and specifically about the teaching of EE, and establish the extent to which these inform the way they approach the topic Water Resources and their Management in Botswana. The topic Water Resources and their Management (WR&M) in Botswana will be used to capture how teachers articulate their knowledge and pedagogical thinking. This topic forms part of the specific objectives for Unit 1.2 on Environment and Humanity in the 3 year Junior Certificate Social Studies syllabus. Water is one of the most important resources that sustain life, so it is paramount that it is managed

wisely and taught effectively to all Batswana at school level. Water resources in Botswana are scarce and therefore motivates my choice for the topic. Since EE is shifting from conservation-protection to sustainability discourses, I consider water management rather than water conservation. In addition, during the conceptualisation of the study, conservation is regarded as one of many management strategies.

1.4.1. Context of the study

In the following section, I describe the water resources in Botswana: their quantity, quality and how they are managed.

Water Resources and their Management in Botswana

The amount of freshwater on earth is actually very small, as most of the water is either salty ocean water (97%) or frozen in the polar ice caps (2%). Less than one percent (1%) of the earth's water is available for sustaining people and life on land (WESSA, 2009). With the world's increasing number of people, some countries, like Botswana, are experiencing water shortages. Since water is one of the most important resources that sustain life, it is therefore paramount that water is managed wisely. This sentiment has been expressed in the 1992 Earth Summit's Values and Principles for a Sustainable Future, the 1997 Earth Charter's Rio Declaration on Environment and Development, the Local Agenda 21 and the Millennium Development Goals (MDG's) in 2000. Water quality and supply of fresh water resources are to be protected from pollution by all means. Societies in the different countries should be sensitised to issues of hygiene and proper management of water. This is in line with Botswana Vision 2016 which advocates provision and access to water for all Botswana citizens (Botswana Government, 1997).

Almost all of Botswana's urban dwellers and 90% of its rural people have access to safe water, a significant fulfillment of the Goal 7, Target 7c of the Millennium Development Goals, which proposes that nations should reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation (Botswana Government, 1997). Botswana, being semi-arid and faced with challenges of periodic droughts and desertification, has a very

limited water supply that is inadequate for its increasing population. Below I describe the water issues in Botswana, using three main sub-concepts on water: quality, quantity and management.

Quantity of water resources

Water resources in Botswana are shared and a scarce resource, unevenly distributed in time and space. This is due to the varied rainfall distribution in the country. The northern part receives more rainfall than other parts of the country, while south-west Botswana has the lowest annual rainfall and the highest levels of unreliability. Although there are many rivers in the country, most of them are ephemeral except the Okavango, Chobe and the Limpopo which are perennial. The limited supply of surface water and the increasing water demand makes ground water highly important, especially in rural communities (Toteng, 2001; Marandu et al, 2010; Botswana Government, 2013). Although groundwater resources contribute up to 65% of the total water available in Botswana, their quantity is limited. Only 1% of this is rechargeable, less than 0.4% of Botswana's total renewable resources (Els & Rowntree, 2001). Research on the water resources in Botswana has indicated that at the current rates of abstraction, the water resources lifetime is limited to decades (Els & Rowntree, 2001; Marandu et al, 2010). Water scarcity factors in Botswana are: Biophysical (e.g. aridity, semi-aridity, unreliable, low and variable rainfall, high evaporation and transpiration rate, few perennial rivers, recurrent drought); Topographic (trans-boundary shared resources, a very flat terrain, hence high costs of exploitation of existing surface water resources, fewer sites suitable for dam and reservoir construction, seepage due to sandy soils); Anthropogenic constraints which result from influences on the natural world (like in the over-pumping of ground water, pollution of ground and surface water) (Toteng, 2008, p. 480).

The quantity principle of sustainability relies on the quality of water not to decline over time, as this may also reduce the total supply of water. It is therefore important to safeguard the quality of water because if the resources decline, heavy economic costs will be imposed on future generations, as they will inherit polluted water.

Quality of water resources

In Botswana, the amount of useable water is reduced by problems regarding the increased pollution of water resources and high levels of water salinity. Water pollution in Botswana is a growing problem that affects both surface water and groundwater. Local studies have indicated that some groundwater sources are contaminated with nitrates due to leakage from septic tanks and pit latrines, agricultural effluent from pesticides, fertilizers and livestock feed-lots, and waste disposal sites and cemeteries, constituting a potential health threat (Botswana Government, 2013; Els & Rowntree, 2001). Discharge effluents from mining operations include high concentrations of various metals polluting the water resources (Botswana Government, 2013; Els and Rowntree, 2001). Factors, such as the insufficient legal protection of groundwater, have led to over-abstraction and subsequent salt-water intrusion into fresh water aquifers. Furthermore, there has been inadequate protection of catchment areas, resulting in pollution from activities such as agriculture and pit latrine toilets in areas with high water tables. Another challenge is that of the natural salinity of groundwater which is common in the western and northern parts of Botswana. The high solar radiation, resulting in high evaporation, leaves salts in the water (Botswana Government, 2013). As a result, the overall quality of groundwater in Botswana is described as relatively poor; hence the potential for large-scale groundwater extraction is low.

Management of water resources

The National Water Master Plans in Botswana have warned of the urgent need to conserve and sustainably use water in Botswana to ensure an adequate supply of safe drinking water for all citizens (Botswana Government, 2013). Therefore, the country faces the challenge to establish a sustainable level of withdrawal from the country's water resources for domestic, industrial and personal needs. This challenge can be addressed through some of the following as recommended in the National Water Master Plans of 1991, 2006 and the 2013 Botswana Integrated Water Resources Management and Water Efficiency (IWRM-WE) Plan:

- extensive water education and awareness campaigns to citizens about efficient water usage
- installation of pre-paid metering systems in major villages
- replacement of automatic flushing urinals with manually operated flushing urinals
- rainwater harvesting in schools and other government institutions
- treatment of waste-water for reuse, increased use of groundwater where there is no alternative
- increasing the use of non-conventional water supply sources e.g. saline, polluted underground water and rainwater harvesting
- negotiations for fair, equitable and sustainable water abstractions from shared water resources, e.g. Chobe river
- creation of more dams and increasing safe yields of water supply through water transfer schemes

(Botswana Government, 2013)

1.4.2. The conceptual progression of the topic Water Resources and their Management in the Botswana school curriculum

Water resources in Botswana are inherently scarce and the quality of water available limits its usability. The opportunities of additional water infrastructure are limited and very costly, so water resources pose a major environmental and development challenge (Botswana Government, 2013). One of the targeted areas to be developed by the Botswana government is the Integrated Water Resources Management & Water Efficiency Plan. This is a social change, which can be achieved by including and integrating in education curricula, "communication strategies and awareness raising aimed at changing behaviour towards water use efficiency and management" (Botswana Government, 2013, p. 9). The Ministry of Education and Skills Development is one of the stakeholders in building capacity on water management, hence the inclusion of the topic of Water Resources and their Management in the curriculum.

This topic is included in most of the subjects at both primary and secondary school level, including Science, Social Studies, Agriculture, Art, Home Economics and others. Since it is EE oriented, it can be integrated into all subjects by the different subject teachers in their planning and implementation of the curriculum. Although I may make reference to other subjects in the curriculum, in this section, I concentrate on the conceptual progression of Water Resources and their Management, particularly in the primary school and Junior Secondary Social Studies curriculum. The topic in lower primary is included under environmental science which, at upper primary, develops into the primary school Social Studies syllabus (see table 1.1.).

Students are exposed to the topic of water in Social Studies in lower and upper primary school, as well as at secondary school level. In the Social Studies curriculum, it is structured so that it progresses from simple concepts to the more complex. The sub-concepts: quantity, quality and management, are addressed at the different levels of students. For example, at the lower primary school level, the focus is more on the identification of the water sources and their use, i.e. water quantity. The students learn to appreciate that water is a limited resource and should not be wasted. They also learn about what could compromise water quality, i.e. pollution and how it can be prevented. Finally, the topic covers keeping water safe and the proper individual care of water, i.e. conservation and the sustainable use of water (management).

At the upper level, students continue to learn about the water resources in the country and their management. At this level, there is more emphasis on management, in particular the conservation of water and other natural resources, like soil and vegetation. The students learn about both local and international conservation agreements/organisation and their role as individuals in appreciating and conserving natural resources.

At the Junior Secondary school, the students learn about the broader interrelationship between humanity and the environment. They study the factors affecting water resources in the country, analyse the role of Indigenous Knowledge Systems (IKS) in the management of natural resources in Botswana and evaluate water conservation practices. Although their focus is more

on the management of water resources, they need the background knowledge on quantity and quality before they are able to learn about the management of water resources. This knowledge they acquire from the lower and upper primary schools.

This analysis of the curriculum forms the basis on which the big ideas on the topic Water Resources and their Management were developed. These ideas are centred around the sub-concepts of quality, quantity and management and are characteristic of the topic Water Resource and Management in the social studies curriculum. These include:

A. Many human activities depend on access to water (*quality and quantity of water*)
B. Although water is a renewable resource, the amount of usable water available is limited by how much can be stored (*water quantity and management*)
C. Water can be transported from one region to another (*water management and distribution*)
D. Water pollution can decrease its usability (*quality and management*)

These big ideas, as well as the sub-concepts on water resources and their management, become very useful in organising the data, as well as in capturing teachers' PCK on the topic.

Table 1.1. The topic on water resources and their management as covered in upper primary and junior secondary school Social Studies curricula

Level / Subject	Summarised syllabus objectives	Focus area and Big idea
Lower Primary (Botswana Government, , 2002a, p. 93 - 102)		
Environmental Science *(Standard 1)*	***Identify sources and uses of water*** *- Identify sources of water, Observe water from different sources, State the uses of water at home, demonstrate the uses of water at home* *- Appreciate that water is a limited resource and should not be wasted*	Big idea A & B Water quantity Management
(Standard 2)	***Keep water safe*** *- distinguish water from other clear liquids (paraffin, oil, gin)* *- Describe ways of saving water, state ways of storing water* *- Describe ways that can make water dirty, State ways in which water can be dangerous*	Big idea B Water quality Management of water
(Standard 3)	***Demonstrate proper care of water*** *Describe: ways in which water can be polluted, ways of disposing of dirty water* *- Make a soak pit* *- List ways of preventing pollution* *- Investigate common water borne diseases in the community, Describe symptoms of malaria and bilharzia (schistosomiasis)*	Big idea D Water quality and management
(Standard 4)	***Demonstrate ways of making water safe to drink*** *- Explain why water may be unsafe to drink, Describe ways of making water safe to drink* *- Demonstrate simple purification of water, demonstrate individual responsibility in using water*	Big idea D Water quality and quantity
Upper Primary (Botswana Government, , 2002b, P. 64 - 67)		
Social Studies *(Standard 5)*	***Develop awareness on natural resource conservation*** *- Identify natural resources in Botswana, Identify different sources of water found in Botswana* *- Describe ways of conserving water soil and vegetation, Analyse the importance of conserving natural resources, Explain community based natural resource management systems (CBNRM), Give examples of communities benefiting from natural management systems, Cite local and international organisations that deal with conservation, State at least five international agreements on natural resource conservation*	Big idea B Water quantity Water management
Social Studies *(Standard 6)*	***Develop awareness on natural resource conservation*** - Explain trans boundary natural resource management systems (TBNRM), give examples on TBNRM efforts , Discuss the role of TBNRM system in conservation and sustainable utilisation of natural resources - Demonstrate appreciation of conservation of natural resources	Big idea C Water management, Quantity and distribution
Junior Secondary School *(Botswana Government, , 2008, p.2)*		
Social Studies *(Form 1)*	**Understand the interrelationship between humanity and the environment** *- Outline the major environmental problems in Botswana and ways of solving them* *- Analyse the role of Indigenous Knowledge Systems (IKS) in the management of natural resources in Botswana* *- Discuss the factors affecting water resources in the country, assess water conservation practises in Botswana*	Big idea A & B Water quantity, quality and management

1.5. Rationale for the study

There are many studies that have been carried out on EE since its inception. Literature reveals that studies conducted in the past three decades have focused mainly on investigating the effects of EE programs on the knowledge, attitudes, skills and behaviours of students (Alvarado, 2010; Hungerford & Volk, 1990). Few studies have explored Topic Specific PCK in relation to the teaching of EE-related topics.

Although possible factors have been identified in undermining the effective implementation of EE, it remains unclear how teachers' beliefs and knowledge influence EE. The study will contribute new knowledge in the area of teacher knowledge and PCK in EE. This knowledge can strengthen existing structures for teacher development in EE and/or ESD. Furthermore, the study will add to the research literature on the relationship between subject matter and PCK, which is an area that has not been thoroughly researched in Botswana. The research will be of interest not only to environmental education policy makers and practitioners, but to all teacher educators whose interests lie in curriculum and instruction issues. The researcher will further recommend best possible ways of bridging the knowledge gaps that exist. The topic Water Resources and their Management in Botswana will be used mainly because of the importance of water as a resource in Botswana.

1.6. Research questions

The study seeks to answer the main question: 'To what extent are Botswana Social Studies teachers able to display Topic Specific Pedagogical Content Knowledge on Water Resources and their Management and what factors influence their approaches to the teaching of this topic?' This main question was divided into four sub-questions as follows:

1. What are teachers' orientations and beliefs about good teaching practices of Environmental Education?

2. What are Botswana Social Studies teachers' understandings of the content knowledge associated with the topic Water Resources and their Management?

3. How do Social Studies teachers represent their topic-specific PCK related to the teaching of Water Resources and their Management?

4. What other available resources might potentially enable teachers to construct PCK?

1.7. Structure of the Thesis

The study comprises seven chapters. Chapter one is an introduction to the study. In chapter two, I discuss the constructs of EE and Water Resources and their Management, and draw the parameters within which the PCK in the study lies. The boundaries and relationship of the concepts for the study were set out in the theoretical framework chosen for the study, still in chapter two. In chapter three, I lay out the research design for the study in relation to the theoretical framework. Chapters four to six address and seek to answer the formulated sub-questions that support the main research question of interest to this study. The last chapter provides a summary of the findings, theoretical contributions, conclusions and recommendations. Below is a synopsis of each chapter.

1.7.1. Chapter 1: Context of the study and research questions

This introductory chapter provides a summary of the study. It begins with a review of the background of the study, the problem statement, the research questions and the rationale for undertaking the research. It outlines the key concepts of the study and also explains how the thesis is structured, as well as the focus of each of the subsequent chapters.

1.7.2. Chapter 2: Literature review and theoretical framework

More research and discourse on effective teaching have drawn the researchers' attention to explore teacher knowledge and practice. Although it is evident from the literature that there have been several studies conducted on teacher knowledge and its influence on teaching, the

area of teacher knowledge, especially subject matter knowledge and pedagogical content knowledge, has not been adequately explored in relation to the teaching of topics on the environment nationally (Botswana) and globally. It is therefore necessary to consider the implications of the current state of teacher knowledge for teaching EE in Botswana. The chapter engages with, and synthesises, various studies on both EE and teacher knowledge, particularly PCK. Furthermore, this chapter establishes a theoretical framework for the study. This is characterised by literature relating to beliefs and PCK.

1.7.3. Chapter 3: Research design and tools of analysis

This section attempts to present the research design for the study. It will address and justify its methodology, the sources of data and collection methods and the organisation and analysis of the data. A case study approach will be used to explore how a group of teachers transforms their understanding and knowledge about EE into teaching about Water Resources and their Management.

1.7.4. Chapter 4: The nature of teachers' beliefs about teaching

The chapter mainly addresses sub-question one on beliefs about good teaching practices. These can be very influential in supporting the formation of constructive personal theories, which, in turn, informs practice (Davidowitz & Rollnick, 2011).

1.7.5. Chapter 5: Beliefs about the environment and Pedagogical Content Knowledge on Water Resources and their Management

This chapter explores teachers' worldviews about the environment and about the teaching of environmental education as per the results from the data, thus responding to research questions one and two. The chapter also explores teachers' content knowledge of water resources and their management in Botswana, and their pedagogical knowledge of how to teach these topics effectively.

1.7.6. Chapter 6: Analysis of teachers' Pedagogical Content Knowledge

Chapter 6 attempts to address research questions three and four, by closely examining how the teachers represent their PCK, particularly: curricula saliency, content representations, what is difficult to teach, student prior knowledge and teaching strategies. This is done for the case study group. The chapter examines the CoRes and the lesson plans, and interprets them to form a picture representing each individual's thinking on aspects of PCK. Furthermore, the chapter explores the potential of other sources, such as textbooks and the EE methodology course that the participants in the focus group embarked on, to allow the teachers to construct PCK.

1.7.7. Chapter 7: Conclusions and recommendations

This chapter concludes the study by considering the discussions from the preceding chapters. It revisits the main findings of the study and uses these and the theoretical framework to answer the research questions. There is also a final reflection on the key argument presented in the study, the methodology, the limitations and areas for future investigation. The conclusion will take into consideration the implications of the findings for teaching in general and for the teaching of topics on the environment in Botswana Junior Secondary schools.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.0. Introduction

There are on-going debates on EE pedagogies and the relationships between Subject Matter Knowledge and Pedagogical Content Knowledge as requisites for effective teaching and learning. In this chapter, I review literature relating the two main fields of EE and teacher knowledge, which form the basis for the theoretical framework. The first section briefly defines EE, identifies its goals, the teaching methods and issues, and describes trends and research on EE teaching. The second section focuses on the various teacher professional knowledge bases required for effective teaching, particularly in EE. At the end of the chapter, I propose a theoretical framework for the study and illustrate how I use it to organise and guide the work.

2.1. Defining Environmental Education

Environmental education (EE) is intended as a lifelong process which encourages students to develop awareness, understanding and appreciation of the environment. It involves recognising values and clarifying concepts so as to enhance the development of skills and attitudes necessary to enable students to appreciate the interrelationships between nature and humans, as well as make informed decisions and act responsibly (Fien & Gough, 1996; Job, 1997; WCED, 1987). Environmental education is aimed at developing awareness and concern about the whole environment and its associated problems, and knowledge, attitudes, motivations, commitments and skills that enable people to work individually and collectively towards solutions of current problems (UNESCO, 1977). Thus, each person needs to have a pronounced and responsible attitude towards the sustainability of the planet earth, an appreciation of its beauty and an allegiance to environmental principles. EE, by its nature, is an open-ended process that requires intensive interaction. It emphasises the importance of integration of knowledge and cross-curricular approaches, and advocates the development of the whole person (Le Grange & Reddy, 1997). It is therefore important that teachers develop teaching strategies that link learning to direct experiences in the environment, and allow students to be drawn into the environmental issues in their local environments.

2.1.1. Teaching approaches in the integration of EE in formal Education

EE can be distinguished from education 'about', 'through' and 'for' the environment (Palmer, 1998; Tilbury, 1995). Fig 2.1 below illustrates how these components of environmental education relate to each other.

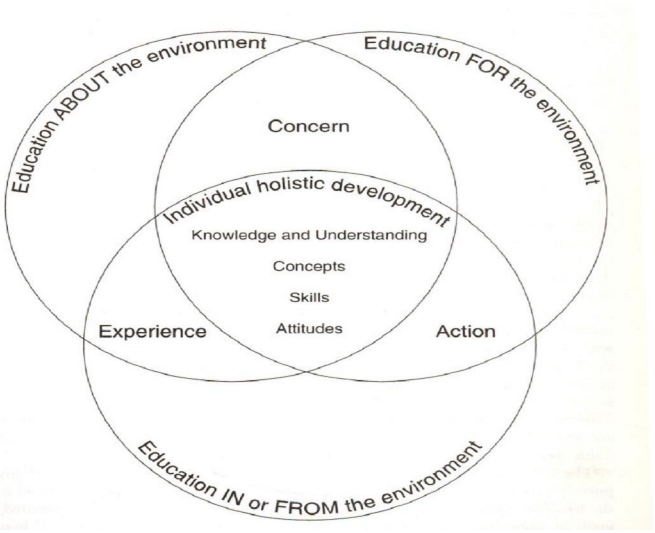


Fig 2.1. Model for teaching and learning in EE (Palmer, 1998, p. 145)

Education *about* the environment

Students need to have knowledge 'about' their environment and how it works. Education about the environment is concerned with developing awareness, knowledge and understanding about human-environment interactions. Students need to learn about natural systems, how they function and their interrelationships to enhance their understanding of the human impact on these systems (Fien & Gough, 1996; Pratchett, 2009; Tilbury, 1995). When learning about the environment, "students develop ecological or environmental understanding, although at times environmental concern may also result" (Tilbury, 1995). This understanding can be developed through investigations of environmental issues, as they allow for the acquisition of knowledge and development of a respect for evidence. The students can ask descriptive questions such as 'what, where, and when?' to obtain information. This process allows students to be active

participants in the learning process (Fien & Gough, 1996; Walker, 1997; Cakir, 2008; Pratchett, 2009).

This approach maintains that, before students can act on a particular environmental issue, they must be familiar with the existence of the issue, know the kind of effective actions available, and have the desire to act (Palmer, 1998). Students can use analysis to progress beyond the descriptive questions, to determine 'the facts' and to understand how these facts relate or fit together. This involves the analytical questions of 'why' and 'how' (Pratchett, 2009). Students need to establish the causes and effects of the problem/issue. They "research and weigh up a whole range of evidence and theories regarding both human and physical influences that are, or may be, at play" (Pratchett, 2009, p. 25). Cognitive knowledge and skill form the basis for further action and personal responsibility towards the environment.

The cognitive domain of knowledge and understanding is insufficient on its own; there is a need for an affective domain in any curriculum model for EE. Questions asked by students should seek to find out about values, attitudes and feelings. These questions, according to Pratchett (2009), help the students evaluate, to understand the responsibilities of humans to other species, the preservation of balance and diversity, and interest for future generations, and also to accept responsibility to maintain a sustainable environment.

Education *in/ from* the environment

Here students' experiences are used in the environment as a medium for education (Fien, 1993). Furthermore, direct involvement with the environment offers reality, provides an opportunity for students to develop practical skills and enhances appreciation for the environment- the beauty of landscapes and the significance of the ecosystems. Education in the environment favours pupil-centred and activity-based learning. In addition, this approach often takes the form of outdoor education. "Whilst education about the environment could be interpreted as involving the 'head', education in the environment can be seen to be concerned with the 'heart'" (Tilbury, 1995). Education *in* the environment is mostly established through

fieldwork, and characterised by experiential learning; the development of environmental awareness and concern is through interaction with nature (Tilbury, 1995).

It is hoped that students are able to realise their responsibility to the environment while involved in engaging with the environment and solving environmental issues (Walker, 1997; Barry, 2006; Pratchett, 2009; Wals et al, 2009). EE *in* the environment is associated with the constructivist or interpretivist image of EE, which promotes students' active learning through environmental experiences. Constructivists maintain that behaviour is situation-specific. They argue that individuals have different conceptions about the world and that these conceptions influence the way they interact with the world and their cognitive systems (Ballantyne and Packer, 1996). This implies that students may learn different things from the same event and apply their understanding in different ways (Gess-Newsome & Lederman, 1999). Cakir (2008, p. 202) asserts that "students' prior knowledge, expectations and perceptions determine what information will be selected out for attention." What students attend to determines what they learn. Therefore, in order to learn a concept meaningfully, students must "... carry out cognitive processes that construct relations among the elements of information in the concept" (Cakir, 2008, p. 202) so that they link what they are with what they are not familiar with (Gess-Newsome & Lederman, 1999; Ballantyne & Packer, 1996; Cakir, 2008).

In order to enhance environmental sustainability in Southern Africa, Lotz-Sisitka (2006) argues that participatory approaches, such as environmental action learning, action research, and inquiry-based methods, critical learning opportunities through debates and group work, as well as opportunities for experiential learning are important to the successful implementation of environment and sustainability education programmes and objectives. According to Fien and Gough (1996, 204) "environmental awareness and concern can also be fostered by linking learning to direct experiences in the environment, and allowing students to become captivated by the complexity and wonder of the natural systems or immersed in the values conflict over particular environmental issues." Providing students with experiences outside the classroom offers reality and enhances opportunities to practice the skills of inquiry, values analysis and clarification and problem solving for everyday situations (Fien, 1993; UNESCO, 2002). Learning

becomes more effective when students use their own experiences to construct understandings that make sense to them, rather than having understanding delivered to them in already organised forms. Learning activities should be based on putting students in the context of what they already know, and applying their understanding to authentic situations (Kauchak & Eggen, 1998). Involvement in the environment will encourage a closer relationship between the student and the environment, thus fostering a greater desire to conserve it. Although teaching and learning should be more practical, where possible it should also be inclusive of the indigenous perspective (Kawagley, 1995; Goduka, 2005) through the integration of the indigenous world view and philosophy. Principles, such as values, traditions and customs help young people to understand and appreciate the world around them.

Teaching the topic Water Resources and their Management in Botswana, the teacher can identify possible outdoor learning areas related to the topic, and design learning activities which enable their students to use their own experiences to construct understandings that make sense to them, rather than be spoon-fed.

Education *for* the environment

Education 'for' the environment is viewed as having a more overt agenda of values education and social change (Job, 1997). The educational goals are seen in terms of promoting lifestyles that are compatible with sustainable and equitable use of resources. This approach should help the students to form opinions about their own place in the environment, and become aware of the effects of the environment on their life, and vice versa, thus creating informed concern for the environment (Palmer, 1998). Students should not remain as passive spectators and recipients of other people's knowledge and thinking. Goh (2009) asserts that behavioural change can be promoted through encouraging action to improve the environment, taking control of their lives, and influencing others to change their lifestyles.

Education *for* the environment regards environmental improvement as an actual goal of education. While education *about* and *in* the environment promotes understanding, appreciation and concern, education *for* the environment goes beyond the acquisition of skills

and knowledge by developing a sense of responsibility and active pupil participation in the resolution of environmental problems (Tilbury, 1995). It adopts a holistic outlook to the study of environmental problems, forming values that affect behaviour and attitudes leading to an environmental ethic. Education *for* the environment integrates crucial education goals within an inquiry-based learning and an issue-based pedagogy (Tilbury, 1995; Pratchett, 2009).

Education *for* the environment has been associated with the socially critical approach to EE. The approach promotes collaborative investigations of real environmental issues by students, teachers and the community. When learning about the environment, students have to know and understand its value; hence the need to critique decisions and expose the platform of values that support them. Once students understand the value of the environment, they will make informed decisions, as well as understand why they were made (Barry, 2006). Students "select, organize and transform the stimuli that impinge upon them" (Bandura, 1977, p. vii). This suggests that people can influence their own behaviour; they are principal agents of their own change. Characteristics of socially critical pedagogy include: value-explicit, political, action-oriented, holistic, issues-based and emancipatory.

Pratchett (2009, p. 25) stresses that sustainability education is most effectively delivered through enquiry-based learning. This can be done by encouraging students to take responsibility for their learning by identifying real issues that concern them in their immediate environment. With the topic Water, these issues would include problems related to water use and its management in their immediate environment. Students in different communities have different experiences with water; therefore, they can investigate the issue with hands-on practical data collection and use the results to take action and see the effectiveness of their actions (Pratchett, 2009). By so doing, they investigate people's motives, omission of information, overlooked issues, assumptions and evidence needed to justify certain positions (Stradling et.al, 1984). They will also search for false analogies, emotive language and prejudice in their analysis. Students may also question their own assumptions and points of view so as to come up with possible solutions to problems and forming their own views on issues (Stradling

et.al, 1984; Gilbert & Hoepper, 1996). It is a possibility that the students may find it confusing and difficult to form views on issues, therefore prompting further inquiry and analysis.

Due to a very limited water supply that is inadequate for its increasing population, Botswana is facing a challenge of ensuring that water is conserved and used wisely, and that it is harnessed in ways that enable an adequate supply of safe drinking water for all citizens. Water conservation should therefore be an objective for all citizens at home, at work, everywhere. Action-oriented, or real-life learning forms an integral stage of the learning cycle, as it encourages students to make an emotional investment in their learning and gives them agency to make change (Walker, 1997; Jensen, 2002). Thus action *for* the environment demands an action-oriented pedagogy. The teacher has to ensure that, as much as possible, they present opportunities for real-life learning to students. Lotz-Sisitka (2006) argues that participatory approaches, such as environmental action learning, action research, inquiry-based methods, critical learning opportunities through debates and group work and opportunities for experiential learning are important to the successful implementation of an environment and sustainability education programme and objectives. These approaches can be used individually or together to complement each other for effective teaching.

2.1.2. Issues and challenges in the teaching of EE globally

The introduction of EE into the school curriculum represents a fundamental challenge to the prevailing conception, organization and transmission of knowledge, resulting in the creation of conflict for teachers with traditional approaches to teaching and learning (Palmer, 1998). Goals of the traditional school promote the acquisition of environmental knowledge and awareness, while EE goals are action-oriented. The implication is that schools have inherent limitations that make it difficult for them to implement goals of education for environmental activism. Palmer (1998) argues that teachers should "improve traditional production practices by providing comprehensive knowledge that cuts across the social and natural sciences so as to nurture a sense of responsibility to the environment among the students". Table 2.1 is an illustrative

summary of the conflict and limitations between Environmental Education and School Learning (Palmer, 1998).

Table 2.1: Summary of Conflicts, inconsistencies and limitations between Environmental Education and School Learning

EE learning	**Traditional School learning**	**EE in Botswana**
Focuses on action-oriented goals	Focuses on acquisition of environmental knowledge and awareness	Focuses on environmental knowledge and awareness, development of skills, desirable environmental attitudes and participation in the care and conservation of the environment
Promotes transformation	Promotes conservation of the existing social order	Promotes conservation of the natural resources and the existing social order
Encourages focus on real environmental problems, calls for inter-disciplinary and flexible inquiry.	Encourages mastery of fragmented facts, concepts and simple generalisations organised loosely within discrete bodies or fields of study.	Encourages focus on real environmental problems
Students are active thinkers and generators of knowledge	Students are usually in the passive position of spectators and recipients of other people's knowledge and thinking	Students are at times passive spectators and recipients of other people's knowledge and sometimes allowed to be active thinkers and generators of knowledge
Content arises as students engage with environmental problems	Content is predefined / predetermined	Content is mostly predefined / predetermined
Learning is holistic and cooperative	Learning tends to be atomistic and individual	Learning is mostly holistic and cooperative
Associated with more complex organisational methods and more risk taking in relation to maintaining order and control	Associated with more traditional subject knowledge acquisition tasks	Associated with more traditional subject knowledge acquisition tasks

EE, as an approach, promotes learning that is student-centred, action-oriented and values-oriented. When students are empowered with the knowledge about the environment and are more involved in the learning process, they become more responsible towards the environment (Barry, 2006; Hawthorne & Alabaster, 1999; Walker, 1997; Lemons, 1989). While students learn about the environment, they also learn about the value of the environment, and can make informed decisions and choices regarding the latter. EE therefore challenges learning tendencies that focus on the acquisition of environmental knowledge and mastery of fragmented facts, concepts and simple generalisations loosely organised within a field of study. Instead, EE promotes learning both in and outside the classroom. Good teachers need to draw on their acquired pedagogical content knowledge to provide situationally appropriate learning

experiences for their students (Barnett & Hodson, 2001, p. 433) and promote environmentally responsible behaviour. An established PCK makes it possible for the teacher to select the appropriate teaching strategy, most useful methods of representation of a topic, and illustrations, explanations, and demonstrations to teach a particular content to a particular group of students (Shulman, 1986) in a particular EE context. A profound PCK may help the teachers to anticipate students' problems regarding certain environmental topics (Van Dijk & Kattmann, 2007), and also enable teachers to design learning activities that will challenge existing conceptions and enable students to construct their personal theories (Cakir, 2008).

This conflict and inconsistency between Environmental Education and School Learning can also influenced by teacher beliefs, their environmental views and the nature of EE.

Teachers' beliefs

There are many influences that shape our beliefs, such as theories of learning, professional training or environmental orientations. Beliefs are "… often times equated with knowledge, attitudes, and personal convictions, or reflect a person's acceptance or rejection of a proposition" (Lumpe, Haney, & Czerniak, 2000, p. 276). A set of beliefs around a particular situation forms attitudes, and these become action plans that guide decisions and behaviour (Pajares, 1992). People act upon what they believe. There is a link between teachers' beliefs about teaching and practices, and subsequently, their PCK (Magnusson et al. 1999; Davidowitz & Rollnick, 2011). Teacher beliefs and attitudes drive important decisions and classroom practice, and these beliefs about teaching develop from years spent in the classroom as both students and teachers (Lumpe et al, 2000; Stuart & Thurlow, 2000). Thus, the decisions made by the teacher on the approaches to teaching and learning rely on the teachers' beliefs about teaching.

Luft and Roehrig (2007) describe beliefs as personal constructs that can provide an understanding of a teacher's practice, guide instructional decisions, influence classroom management and serve as a lens of understanding for classroom events. They identify five kinds of beliefs: traditional, instructive, transitional, responsive and reform-based. These beliefs

constitute a spectrum, with traditional and instructive categories representing teacher-centred beliefs, while responsive and reform-based responses represent student-centred beliefs. The transitional category reflects a view of students that focuses on primarily behaviourist and affective attributes of students, with not always cognitive involvement. The traditional responses are based on facts, rules and methods that are transferable (Luft and Roehrig, 2007). The traditional and instructive categories could be related to the traditional approaches to EE, while the transitional and responsive could be associated with the progressive approaches to EE. Table 2.2 below summarises the five belief categories.

Table 2.2. A summary of the beliefs categories by Luft and Roehrig (2007)

Category	Code	Description
Traditional	1	Focus on transmission of information and structure
Instructive	2	Focus on providing experiences and monitoring of students actions or behaviours during instruction (teacher-focus, or teacher decision)
Transitional (Cognitive and affective)	3	Focus on teacher/student relationships, subjective decisions, or affective response.
Responsive	4	Focus on collaboration, feedback, or knowledge development (designing the classroom environment to enable the students to interact with each other and their knowledge)
Reform-based	5	Focus on mediating student knowledge or interactions.

Beliefs play an important part in how teachers consolidate knowledge and information. They are crucial in helping teachers "adapt, understand, and make sense of themselves and their world. How and what teachers believe has a tremendous impact on their behaviour in the classroom (Moseley & Utley, 2008, p. 16). Beliefs as well as values are "… not minor, they are fundamental. The beliefs and values provide the submerged 'bulk of the iceberg' upon which any particular teaching technique rests" (Moseley & Utley, 2008, p. 16). Teachers' beliefs also influence and impact on their goals for teaching. Depending on their beliefs about what constitutes good teaching, teachers may have different goals for teaching, even in EE. Some of these goals for teaching could be: student attitude and behavioural change, skills development, real-world connections, student development, transmitting facts or knowledge, learning, humanistic, improvement for pedagogy, social reform/good citizenship or knowledge

acquisition (Magnusson et al, 1999). Furthermore, student activities largely depend on the skill the teacher believes is important to develop (Magnusson et al, 1999).

According to the Botswana Government (1993), teachers are perceived as agents of all curriculum implementation. They are entrusted to mould the character of the student ; help student s acquire useful knowledge; be good role models; be intellectually capable; competent in their field; possess mastery of the subject matter and pedagogical skills, educational understanding and an appropriate personality for teaching (Botswana Government, 1993, p. 340). Although brief, these are in sync with the South African education policy, which also describes the *roles*, associated set of *applied competences* and *qualifications* for the development of educators (see Table 2.3). These also serve as a description of what it means to be a competent educator.

Table 2.3. Roles of the teacher (South African education Policy; Norms and Standards for educators, 2000)

Roles of the teacher	**Description** The educator will:
1. Learning mediator	- mediate learning in a manner \sensitive to the diverse needs of student s, including those with barriers to learning; - construct learning environments that are appropriately contextualised and inspirational; communicate effectively showing recognition of and respect for the differences of others - Demonstrate sound knowledge of subject content and various principles, strategies and resources appropriate to teaching.
2. Interpreter and designer of learning programmes and materials	- understand and interpret provided learning programmes, - design original learning programmes, - identify the requirements for a specific context of learning and select and prepare suitable textual and visual resources for learning - Select sequence and pace the learning in a manner sensitive to the differing needs of the subject/learning area and student s.
3. Leader, administrator and manager	- make decisions appropriate to the level, manage learning in the classroom, - Carry out classroom administrative duties efficiently and participate in school decision making structures in ways which are democratic, which support students and colleagues, and which demonstrate responsiveness to changing circumstances and needs.
4. Scholar, researcher and lifelong student	- Achieve on-going personal, academic, occupational and professional growth through pursuing reflective study and research in their learning area, in broader professional and educational matters, and in other related fields.
5. Learning area/subject/discipline /phase specialist	- be well grounded in the knowledge, skills, values, principles, methods, and procedures relevant to the discipline, subject, learning area, phase of study, or professional or occupational practice - know about different approaches to teaching and learning (and, where appropriate, research and management), and how these may be used in ways which are appropriate to the student s and the context - Have a well-developed understanding of the knowledge appropriate to the specialism.
6. An assessor	- Understand that assessment is an essential feature of the teaching and learning process and know how to integrate it into this process. - Have an understanding of the purposes, methods and effects of assessment and be able to provide helpful feedback to students. - Design and manage both formative and summative assessment in ways that are appropriate to the level and purpose of the learning and meet the requirements of accrediting bodies. - Keep detailed and diagnostic records of assessment. - Understand how to interpret and use assessment results to feed into processes for the improvement of learning programmes.
7. Community, citizenship and pastoral role	- practise and promote a critical, committed and ethical attitude towards developing a sense of respect and responsibility towards others - Will uphold the constitution and promote democratic values and practices in schools and society. - Will demonstrate an ability to develop a supportive and empowering environment for the student within the school and respond to the educational and other needs of leaners and fellow educators. - develop supportive relations with parents and other key persons and organisations based on a critical understanding of community and environmental development issues

The outlined roles of the teacher establish the key strategic objectives for the development of learning programmes, qualifications and standards for educators. These roles and competences must be integrated in the learning programme and should inform the exit level outcomes of a qualification as an educator (South African education Policy; Norms and Standards for educators, 2000). They also describe what it means to be a competent teacher. These roles provide a broader picture of a teacher. My study explores teachers' beliefs about teaching in general and teaching in EE, therefore exploring different literature on beliefs about teaching helps inform my theoretical framework, as well as provide an organising framework for my analysis. In consideration of all the different definitions and perceptions on teacher beliefs from different authors, I consider teacher beliefs as teachers' ways of thinking and understanding of their practice that enable them to mediate learning in effective ways (Ramsden, 2003; Luft & Roehrig, 2007; Morrow, 2007). Working cooperatively with their students helps them improve their understanding.

Since one of the research questions of my study seeks to explore how teachers' beliefs influence their approach topics on the environment, it is important to highlight that teachers' environmental views or orientations, like their beliefs about teaching, influence the way they approach topics related to the environment. I also include these different beliefs and environmental views to ease the analytical processes for the study.

Teachers' environmental views

Teachers' environmental beliefs, knowledge and skills, and their environmental programmes, provide evidence of the way they view environmental education (Robertson & Krugly-Smolska, 1997). Two major environmental perspectives dominate views on the environment: the technocentric and the ecocentric. These perspectives impact on how teachers implement EE in the schools. The technocentric perspective "views the earth as machine whose operations can be understood, predicted and managed using the tool of science" (Job, 1996, p. 25), thus the functioning of the earth can be understood through scientific investigation. This view holds that future states can be changed through environmental management. People are predominant

over all other forms of life, the earth included, and the whole is viewed as the sum of the parts. The human point of view is paramount.

Table 2.4. Summary of the environmental view points

Environmental viewpoint	**Depiction of the environment**
Ecocentric (nature centred)	- Life centred - Respects the rights of nature and the dependence of humans on nature - Holistic world view. - Minimum disturbance of natural processes. - Integration of spiritual, social and environmental dimensions. - Sustainability for the whole Earth - Self-imposed restraint on resource use.
Technocentric/Anthropocentric	- Human centred - Humans are viewed as the dominant species on earth and we can manage the environment to suit our own needs - Other species can only therefore have value if they are useful to us - Technology can keep pace with and provide solutions to environmental problems. - Resource replacement solves resource depletion. Need to understand natural processes in order to control them. - Strong emphasis on scientific analysis and prediction prior to policy-making. - Importance of market, and economic growth.

The ecocentric approach (e.g. Aldo Leopold, Arne, Naess and George Sessions) (Nelson, 2008), on the other hand, is based on the notion of a sustainable earth with all resources, species and landscapes being equal. Humankind is "… not perceived as superior or separate from the environment" (Ballantyne & Packer, 1996, p. 29). The ecocentric perspective acknowledges the importance of developing policies that are aimed at reducing consumption and allowing for fair resource utilisation.

The technocentric perspective is characteristic of increased levels of consumption and development of technology by humans (see table 2.4). Job (1996) asserts that the human population continues to manipulate the resources found on earth and, as these become depleted, they find ways through technology to replace them. Examples of scholars for this view include; Paul R. Ehrlich, Reverend Thomas Robert Malthus, Professor Albert Bartlett and Friedrich Hayek (Job, 1996).

Robertson & Krugly-Smolska (1997) further identify six different conceptions about EE among teachers (see table 2.5). These conceptions surface in some researchers' views about the emphasis of EE. As a result, confusion prevails for teachers when researchers have different ideas about where the emphasis lies.

Table 2.5. Six different conceptions about EE among teachers (Robertson & Krugly-Smolska, 1997, p. 311)

Conception	**Description**
utility	environmental education is regarded as a means for learning about resource management, conservation or preservation;
aesthetics	focus is exposure to, and appreciation of, landscapes and wildlife
ecology	more science-based approach to study aspects like plants, animals, energy and relationships
environmental ethics	concerned with clarifying the rights of, or consideration for, all species and the responsibilities of humans
deep ecology	takes ecology and ethics a step further to understand, from a holistic perspective, interconnections and the effects of human actions and includes a spiritual dimension
Socio-cultural criticism	the examination of human beliefs and behaviour in the light of environmental impacts, including political and economic influences, and how these affect the water, air, soil, and therefore all species dependent on these for life

Teachers in EE find themselves torn between several environmental paradigms. This has implications in the way they teach about the environment. The ecocentric approach leans towards the wellbeing of nature while the technocentric places the consuming culture before nature. Is it therefore possible for the teachers to maintain a balanced view in their delivery or do they consciously or otherwise project a technocentric approach? Job (1996) argues that the latter tends to dominate most of our deliberations as educators and that this might be done consciously or unconsciously, depending on our knowledge and understanding of environmental issues. To add to this uncertainty, is the tension between conservation and sustainable development in EE. These different conceptions about EE among teachers were useful for the analysis stage, particularly in understanding teachers' beliefs about the environment and how these influence the teaching of EE-oriented topics.

Tension between conservation and sustainable development in EE

The tension between conservation and sustainable development (SD) poses a challenge to the implementation of EE by teachers. It is not clear which one of the two should be given more emphasis. Both are fighting for territory and influence. Education for sustainable development (ESD) emanates from the concept Sustainability which dates back to the 1980's and made the EE vocabulary around the 1990's (WCED, 1987 & IUCN 1980). Sustainability refers to the "need for reconciliation between economic development and environmental conservation as well as the need to place and understanding of the environment concerns within socio economic and political context" (Tema, 1999, p. 221). This is a combination of environment and developmental concerns.

The scope of EE before the Rio Summit for sustainable development in 1992 was in the direction of conservation of the natural environment, and consequently links with various dynamics of society: economic, cultural, political, religious, social, scientific and technological systems, were poor (Tema, 1999). At Rio, Sustainable Development (SD) was introduced and reinforced, consequently necessitating the move from EE to SD without forgetting environmental conservation (Tema, 1999). Education is seen as playing a key in remedying environmental problems, promoting SD and improving capacity to address environmental and development issues; this gave rise to EE.

Agenda 21, the official document of the Rio Summit for sustainable development called for the reorientation of EE towards sustainability. Forbes and Zint (2009, p.1) assert that "EE and ESD share many similar characteristics. Both are multidisciplinary, emphasize behaviour change, often address controversial issues, and wrestle with the same challenges associated with their inclusion in the school curriculum". However, while compatibility exists between environmental education and ESD, the trend towards ESD represents a clear shift in focus from specific environmental issues to the broader context in which they exist. There is growing recognition that it is critical to not only emphasize the environmental dimensions of a given issue, but social, cultural, economic and political ones as well.

Although sustainability is an important idea, it has limitations. ESD "falls short of EE's largely unrealized potential. Sustainability will have a future if we see it as a stepping stone in the evolution of our thinking and if we recognise the limitations of the term. The challenge is to go beyond sustainability" (Jickling, 1999, p. 111). EE and ESD are both "concerned with achieving the same ends: enabling students to question unsustainable practices and participate in changing these practices" (Gough, 2006, p. 49). The possible relationships put forward by Cartea (2005) include: EE as part of ESD, ESD as part of EE, EE and ESD as partially overlapping fields or ESD as a stage in the evolution of EE. Cartea (2005) found out that more people perceive ESD as a stage in the evolution of EE. McKeown and Hopkins (2003) suggest that EE and ESD are discrete and yet complementary. Furthermore, these "two influence and benefit from each other while they maintain separate agendas, priorities and pragmatic development" (Ketlhoilwe, 2007, p. 32). Table 2.6 briefly sums up the focus areas between EE and ESD, whether the emphasis is on conservation or sustainable development, by summarising the similarities and differences between the two.

Table 2.6. Summary of the relationship between EE and ESD

	EE	**ESD**
Focus	EE has traditionally been problem focused: its goals and objectives have usually referred to the environment and its associated problems, and resolving these (Gough, 2006)	ESD encompasses EE, setting it in a broader context of socio-cultural factors and the socio-political issues of equity, poverty, democracy and quality of life, as well as a development perspective on social change and evolving circumstances (Gough, 2006)
	Concerned with the interrelationship and interconnectedness between human and natural systems thus more focused on the naturalist and conservationist deviations and equating environment to nature (Palmer & Neal,1994; Cartea ,2005)	Encourages students to explore links between personal lives and wider environmental and development concerns (Tema, 1999; Wals, 2010; Chenrachasith & Chen, 2008)
Goal	Views environment in its entirety, including social, political, economic, technological, moral, aesthetic and spiritual aspects (Palmer & Neal, 1994; Gonzalez-Guadiano, 2005)	Focuses on developing closer links between environmental quality, ecology and socio-economic and political threads (Tema, 1999; Gonzalez-Guadiano, 2005; Chenrachasith & Chen, 2008; Wals, 2010)
Nature	Interdisciplinary and holistic in nature and application (Palmer & Neal, 1994).	Holistic in nature (Tema, 1999)
Teaching approach	Encourages clarification of values and the development of values-sensitive environment (Palmer & Neal, 1994).	Teaching not limited to values but extends to values required for sustainable living (Chenrachasith & Chen, 2008; Tema, 1999)
	Seeks to interest and involve students in world problems by encouraging the development of sensitivity, awareness, understanding, critical thinking and problem-solving skills (Palmer & Neal, 1994).	Promotes issue-based learning (identifying issues, investigating them, finding solutions, acting out actions that address issues, evaluating the impact of the actions (Tema, 1999; Wals, 2010; UNESCO, 2002)
	Encourages active responsibility, participation and hands-on experience in the learning (Palmer & Neal, 1994).	Action-oriented (ability to participate in resolution of problems through: negotiation, persuasion, consumerism, political and legal action as well as eco-management) (Wals, 2010; UNDESD, 2004)

Scholars such as Jickling (1999) argue that ESD, as a concept, has not been adequately conceptualised; therefore, there is a need to further explore the concept and what it really entails. Huckle and Sterling (1996) claim that since ESD is not replacing EE, there is no reason why they should not coexist. However, teachers in the schools, particularly in Botswana, are not on board with these developments and debates on EE and SD/ESD. They are also not necessarily aware of the distinction between conservation and sustainable development. Hence they continue with the status quo and are not necessarily implementing EE according to international standards. This shows some inadequacy in the required teachers' professional knowledge bases, particularly for EE.

2.1.3. Trends and empirical studies in EE teaching

Most research on EE has for the past two to three decades focused on the impact of EE on students (Palmer, 1998; Alvarado, 2010) and the causal role of environmental concern in the formation of environment-related behaviours (Van Petegem et al, 2007). Several theoretical frameworks have been developed to uncover the relations between attitudes, concern and behaviour, and to explain the obstacles to pro-environmental behaviours, but no model has been singled out as the most sufficient (Van Petegem et al, 2007). An extensive review of empirical studies on EE and teaching revealed some recurring themes, including: conceptions of EE, environmental concern, environmental citizenship behaviour, environmental action and/or action competence (related to methods and their impact), teacher knowledge, content knowledge (CK), subject matter knowledge (SMK), pedagogical content knowledge (PCK) and beliefs and goals in teaching EE (related to teacher knowledge and practice) (Alvarado, 2010). Below I briefly describe the two dominant themes that relate to methods and their impact, as well as teacher knowledge and practice.

Methods and impact of EE on students

Most findings have associated effective learning of EE with methods that are student-centred and action-oriented, such as: outdoor learning experiences, inquiry based learning, civic clubs,

school plays and indigenous knowledge. Ajiboye and Silo (2008) argue that there is a lack of students' genuine participation in environmental issues; thus, there is more rhetoric than meaningful practice and environmental citizenship education is neglected. Most EE instruction in Botswana primary schools is characterised by lack of meaning, presentation of isolated facts without meaningful context and no connection between classroom content and student experiences or contemporary issues. Consequently, few students participate in environmental action or sustain their local environment through personal initiatives (Ajiboye & Silo, 2008). Citizenship education and environmental education are intimately related and their connection allows students to understand how their actions can influence their environmental welfare and that of their communities. Components of environmental citizenship include environmental information, awareness, concern, attitudes/beliefs, education and training, knowledge, skills, literacy and responsible behaviour (Hawthorne & Alabaster, 1999).

Introducing students to outdoor experiences, inquiry learning, civic clubs and school plays exposes them to various ecological and environmental issues which ultimately help them to develop a sense of actual obligation and stimulate an inclination towards the environment and nature usage (Tal & Argaman, 2005; Van Petegem et al, 2007; Ajiboye & Silo, 2008). The students also develop observation skills and acquire the necessary knowledge that enables them to contribute positively to addressing the environmental problems in their local communities (Ajiboye & Silo, 2008; McNaughton, 2007; Van Petegem et al, 2007). In addition, action-oriented classroom interventions, such as environment clubs and celebrating environmental days, have positive effects on responsible environmental behaviour (Van Petegem et al, 2007). This entails direct environmental action (Jensen, 2002) - personal actions that are directly related to environmental improvement.

Teacher knowledge and practice

Literature has argued that teaching and learning in EE is more effective through student-centred, action-oriented and constructivist-oriented learning initiatives (Ballantyne & Packer, 1996; Fien & Gough, 1996; Walker, 1997; Cakir, 2008). This is a challenge for teachers who, like

their students, are subject to conceptual confusion due to lack of awareness of the complex and multi-dimensional nature of the environment and the underlying theoretical and scientific views (Van Petegem et al, 2007). Teaching in EE, especially in inquiry-oriented teaching, places high demands upon teachers' content knowledge (CK), which must be deeper and broader than in the traditional "knowledge transmitting method" (Shulman, 1987; Tal & Argaman, 2005).

Action-oriented and inquiry-based learning in a real-life context requires more involvement of the teacher than traditional learning. Tal and Argaman (2005) observed that due to insufficient content knowledge, the teachers tended to be constantly involved in most stages of their students' work. The teachers need to allow their students to challenge their own thinking and mistakes (Tal & Argaman, 2005). This ability relies on an adequate content knowledge. The teacher's lack of prerequisite knowledge on integrating EE has resulted in insufficient impact of EE on the knowledge, attitudes and skills of students (Ajiboye & Silo, 2006; Tal & Argaman, 2005; Alvarado, 2010). This implies that teachers must have a comprehensive knowledge of environmental concepts to be better environmental education teachers. Nevertheless, teachers' knowledge of environmental themes is still a challenge, and aspects, such as values and participation, are still not observable in their teaching and planning (Cinquettia & de Carvalho, 2007).

In their study, Bozkurt and Kaya, (2008) argue that Turkish prospective science teachers have not had appropriate pedagogical knowledge, especially with regard to the components of curriculum knowledge, knowledge of students' learning difficulties and knowledge of instructional strategies involving the topic of ozone layer depletion. There was no evidence of building on students' pre-instructional knowledge, which showed that the teachers were unaware of students' likely misconceptions. Teaching strategies were teacher-centred rather than student-centred, characterised by telling or lecturing, e.g. the provision of comprehensive verbal explanations to students about ozone layer depletion (Bozkurt & Kaya, 2008). These findings were similar to those by Dickerson, Penick, Dawkins and Van Sickle (2007), who found that there was inadequate formal instruction, lack of attention to students' spatial reasoning

abilities and difficulty in designing appropriate assessments for students. Teachers' conceptual frameworks for teaching impacted on the strategies that teachers considered, from which it may be concluded that subject matter knowledge influences choice of teaching strategies (Magnusson et al, 1999).

In their study on how primary pre-service teachers plan for teaching, learning and acting in environmentally responsible ways, Gooch, Rigano, Hickey and Fien, J. (2008) found that teachers' plans often lacked consistency between the pre-service teacher's beliefs, intended outcomes, learning experiences and assessment tasks (Gooch et al, 2008). Therefore they argued that teachers should align their teaching unit plans with their personal convictions, such as beliefs about issues, outcomes (statements signalling what students will know and be able to do), students' learning experiences and assessments, informing and bringing awareness to students about environmental issues and empowering them to act in environmentally responsible ways (Gooch, et al, 2008; Alvarado, 2010).

2.1.4. Literature gap

Although there has been an increase in research on a variety of themes, most studies are persistently concerned about the methods, resources, results and efficiency of EE, hence the need for more research on teachers per se, their knowledge and teaching practice, constructivist teaching and learning (Shulman, 1986/7; Ballantyne & Packer, 1996). Another under-researched area covers beliefs and attitudes that teachers bring to the teaching of EE (Palmer, 1998; Moseley & Utley, 2008; Alvarado, 2010). Most of the identified and reviewed empirical studies have been conducted outside Africa (e.g. Michigan, Turkey and Brazil); consequently the need for more research in the Southern African context is imperative.

Walker (2006) argues that, while it is important to research teacher thinking to understand teaching practice, it is also necessary to explore the relationship between "… espoused theories (what do teachers think/think they want/would like to do) and 'theories in use' (what do teachers actually do) and also between intended lesson outcomes for students and expressed/observed/measured outcomes" (Rickinson & Robinson, 1999 as cited in Nickel, 2007,

p. 560). This will involve exploring teachers' conceptions of what environmental education entails, that is, examining teachers' beliefs, their SMK, PCK and teacher practice and the impact on students' environmental literacy and behavioural change, as well as what happens in the classroom (Robertson & Krugly-Smolska, 1997).

2.2. Teacher knowledge domains

This section will explore issues around teaching as a professional practice, the professional development of teachers, the knowledge bases for teaching, the place of subject matter knowledge in effective teaching and the construct of PCK, how it can be captured and portrayed.

2.2.1. Professional development of teachers

There is an argument that teaching can be a demanding, subtle, nuanced and frightening activity and that it deserves professional status (Shulman, 1986; Baratz-Snowden, 2005; Darling-Hammond, 2006). Shulman (1986) argues that the teaching profession has been "...trivialised, its complexities ignored, and its demands diminished. Teachers themselves have difficulty in articulating what they know and how they know it" (Shulman, 1986, p. 222). Although teachers as professionals may be different, there are common practices of effective teaching. These include: knowledge of student s and their development in social contexts (learning), knowledge of subject matter and curriculum goals (educational goals and purpose for skills content, subject matter) and the knowledge of teaching (content and content pedagogy, teaching diverse student s, assessment and classroom management) (Darling-Hammond & Baratz-Snowden, 2005, p. 5). These echo Shulman's (1987) teachers' professional knowledge bases (TPKB) for teaching which include specific categories of teacher knowledge as listed and described in Table 2.7. Shulman (1986) has argued that there exists a "knowledge base for teaching" which can be used to understand the education and performance of teachers. This is "a codified or codifiable aggregation of knowledge, skill and understanding, and technology, of ethics and disposition, of collective responsibility – as well as a means of representing and communicating it" (Shulman, 1986, p. 222). These knowledge bases for

teaching are; Subject matter Knowledge, Pedagogical Content Knowledge, Curriculum Knowledge, General Pedagogical Knowledge, Knowledge of Students, Knowledge of Educational, Contexts and Knowledge of Educational Ends (see table 2.7 below).

Table 2.7: Teachers' Professional Knowledge Base Categories (Shulman, 1987)

Teacher Knowledge Category	**Definition**
Content Knowledge	This refers to the amount and organization of knowledge per se in the mind of the teacher. Academic related knowledge, i.e. structures, rules, and conventions for organizing and using information or data.
Pedagogical Content Knowledge	The combination of content and pedagogy, into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of student s and presented for instruction
Curriculum Knowledge	Materials and programs that serve as "tools of the trade" for teachers
General Pedagogical Knowledge	Principles of classroom management and organization unrelated to subject matter - and applicable across e.g. maintaining appropriate discipline, using class time efficiently, and communicating instructions / expectations clearly.
Knowledge of Student s	Specific understanding of the student s' characteristics which can be used to specialize and adjust instruction (e.g. the prior knowledge of student s, their interests , their diverse abilities and ways of learning)
Knowledge of Educational Contexts	An understanding of the classroom, the governance and financing of school districts, the character of school
Knowledge of Educational Ends	The purposes and values of education as well as their philosophical and historical grounds

Literature shows that up until the 1980's, knowledge bases emphasized in teacher education lacked focus on the content knowledge of the teacher. This was termed the "missing paradigm" by Shulman (1986). This suggests that teachers' management of both classrooms and the ideas within classroom discussions are prerequisites for good educational practice and serve as guides to the design of better education (Shulman, 1986).

Professional development seems an especial challenge in Botswana, as there are few opportunities for teachers to attend in-service workshops or training on making the infusion of content and pedagogy easier for implementation (Maruatona, 2002; Molosiwa, 2010; Hunter & Molapo, 2014). Research in Botswana has also indicated that teacher-centred pedagogy is still very prevalent, regardless of new policies promoting more progressive student-centred instruction (Hunter & Molapo, 2014; Maruatona, 2002; Moswela, 2006). This is attributed to

teacher training that tends to focus more on content than pedagogical content knowledge. Didactic teaching methods, over-reliance on textbooks and the prescriptive national curriculum limit teachers from using the content, combined with the methods of teaching, to enhance learning. Instead, it reinforces teacher authority and limits students' engagement (Maruatona, 2002; Tafa, 2004). The challenge is, therefore, to shift towards a more progressive student-centred instruction by improving teacher training and providing more professional development opportunities.

Since the focus of my study is on how the beliefs and knowledge of teachers influence effective teaching, I have narrowed my literature references to focus more on subject matter knowledge for teaching (SMK) and Pedagogical Content Knowledge (PCK).

2.2.2. Teachers' understanding of subject matter knowledge (SMK)

Subject matter knowledge (SMK) is arguably one of the knowledge bases required for teaching (Shulman, 1986). This makes the mastery of subject matter one of the essential aspects of teacher capacity. Shulman (1986) contends that, in their endeavour to find the forms of teacher behaviours that would most effectively promote student learning, policy-makers ignored subject matter as a central aspect of classroom life, giving rise to the "missing paradigm" problem. There are different conceptions of SMK by different scholars. In describing SMK, Shulman (1986) equates content knowledge to subject matter knowledge. CK is referred to as "going beyond knowledge of the facts or concepts of a domain. It requires understanding of the structures of the subject matter" (Shulman, 1986, p. 9). SMK, according to Shulman, is one of three distinct categories, namely, subject matter knowledge, pedagogical knowledge and curriculum knowledge (Shulman, 1986, p. 9). On the contrary, Cochran & Jones (1998, p. 708) characterise SMK as an umbrella conception with four components that include: content knowledge (the facts and concepts of the subject matter), substantive knowledge (the explanatory structures or paradigms of the field), syntactic knowledge (the methods and processes by which new knowledge in the field is generated), and the beliefs about the subject matter (students' and teachers' feelings about various aspects of the subject matter).

My study does not consider the entire SMK for EE but concentrates around content knowledge pertaining to water resources and their management. Therefore I have decided to adopt the term content knowledge (CK), which I use to represent the facts and core concepts of water resources and management, understanding of the big ideas of the content to be taught and the organising structures of the subject matter (Shulman, 1986; Cochran–Smith et al, 1998; Wiggins & McTighe, 2006). I also consider how content knowledge is arranged for effective scaffolding of student learning (Gess-Newsome, 1999).

Morrow (2007, p. 82) asserts that "content knowledge is a necessary pre-condition for any teaching". Thus the "teacher needs to know how to make content accessible to the students she is teaching, and this requires an articulated conceptual understanding of the content" (Morrow, 2007, p. 84). The teacher needs to understand the content in a way that is easily accessible and represent it in ways intelligible to others. Ideally, teachers must have an in-depth knowledge of the subject area themselves, to enable the teacher to develop suitable instructional strategies for their students, to provide the students with numerous examples related to the concept, and to provide concrete and basic factual knowledge on the concept being taught (Cochran & Jones, 1998; Darling-Hammond & Baratz-Snowden, 2005; Shulman, 1986; Bransford et al, 2000). Literature in Botswana identifies lack of CK and/or SMK as one of the challenges for effective teaching of EE (Mosothwane, 2002; Mogotsi, 2007; Ketlhoilwe, 2003/7). Teachers in Botswana therefore need to possess a rich knowledge of the facts and concepts of the subject matter (Cochran & Jones, 1998; Darling-Hammond & Baratz-Snowden, 2005; Shulman, 1986; Bransford et al, 2000), particularly on Water Resources and Management, for effective teaching of the topic.

In EE, students are expected to acquire knowledge *about* the environment, how it works, interrelationships between natural resources and how they depend on each other. Learning can be done *in/from* and should encourage action *for* the environment (Palmer, 1998). Since EE methods promote learning which is student-oriented and inquiry-based, it is necessary for teachers to have in-depth SMK (Tal & Argaman, 2005). Strong background knowledge of content which allows the teacher to help students with comprehensive environmental

investigations, is reliant on the teachers' subject matter knowledge, their knowledge of scientific methods and their previous experiences in inquiry-based learning (Moseley & Utley, 2008; Bransford et al, 2000). It is also paramount for teachers to organise systematic learning, by identifying "what is possible for the particular students in question to learn and expertise in inventing ways of enabling them to learn the relevant content" (Morrow, 2007, p. 85). Therefore, it is also important for teachers to understand the subject in ways that can be communicated to different students (Cochran-Smith et al, 2008) so as to ensure higher outcomes in student learning (Berliner, 1992; Darling-Hammond & Baratz-Snowden, 2005; Shulman, 1986; Bransford et al, 2000; Morrow, 2007).

Complementarily, the importance of acknowledging pedagogical understanding and skill, as well as content knowledge, has been argued by Shulman (2004) as equally important in the development of a teacher and enhancing the effectiveness of instruction. It is expected that the teachers' CK should enable them to understand "why a given topic is particularly central to a discipline whereas another may be somewhat peripheral. This will be important in subsequent pedagogical judgments" (Shulman, 1986, p. 9). For a teacher who integrates EE in his/her teaching, this would mean having a broad knowledge about EE and its goals, a combination of content and pedagogy required for EE topics, curriculum goals in relation to EE, materials needed, principles of classroom management and organization. Furthermore, the teacher needs to have specific understanding of the students' characteristics and knowledge of the big picture surrounding the classroom, as well as the purposes and values of education in the country.

Although there is some significant literature that indicates that content knowledge has an influence on teacher effectiveness and student learning, and is essential for the development of PCK, there are still arguments that CK alone may not guarantee effective teaching. Nevertheless, knowledge and understanding of the concepts within the subject or topic to be taught logically precede a process of transformation of the content to enable learning (Shulman, 1987; Morrow, 2007). That is, teachers should use their inherent logic of the content and use that as a basis on which to organise systematic learning (Morrow, 2007). Teachers need

to know the content knowledge, as well as how it can be transformed into representations that are comprehensible to a group of students with diverse interests and abilities.

Pedagogical reasoning and action

Good teaching should not only be about knowledge but also the capability to reason soundly about teaching, that is, teachers allowing themselves to think "... about their actions and a sufficient repertoire of content, principles and experience from which to reason" (Mavhunga, 2012). There is need for consideration of comprehension and reasoning, as transformation and reflection in teaching. The transformation of the content in appropriate ways for others to learn culminates in a pedagogically reasoned "plan, or set of strategies, to present a lesson, unit or course" (Shulman, 1987, p.104). Teachers should use their knowledge base to provide grounds for choices and action by organising and mediating systematic learning. The "model of Pedagogical Reasoning and Action" *(*Shulman, 1987), identifies teaching as a complex process, and provides a framework for linking the knowledge that teachers possess, their thinking and their classroom actions. It represents a cycle that involves comprehension, transformation, instruction, evaluation and reflection (see Fig 2.2.), and this cycle ultimately leads to new comprehension about teaching and learning.

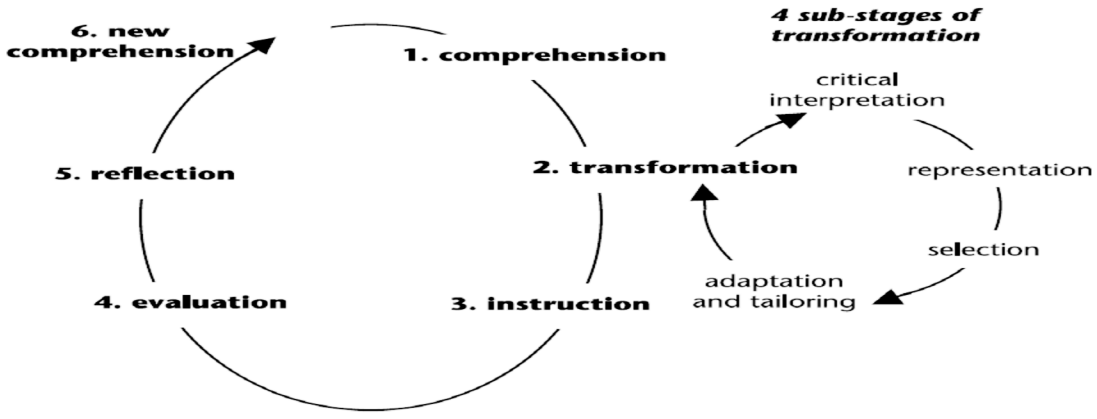


Fig 2.2. Shulman's Model of Pedagogical Reasoning and Action (Bishop & Denley, 2007, p. 18).

This model of Pedagogical Reasoning and Action (PRA) suggests how various categories of teacher knowledge can inform both pedagogical thinking and classroom action during instruction (Rusznyak, 2009). I have extracted and adapted the summarized processes of PRA (see table 2.8) as explored in Rusznyak (2009, p. 110 – 113).

Table 2.8. Summary of Shulman's model of pedagogical reasoning and action and its associated teacher knowledge bases

Name of pedagogical process	Description of pedagogical action	Associated categories of teacher knowledge
1. Comprehension	Teachers draw on their subject matter knowledge as well as their knowledge of educational goals, purposes, and values and the philosophical and historical grounds on which these goals are based (Shulman, 1986).	Subject matter knowledge Goals, purposes and values
2. Transformation	Transforming the content culminates in a pedagogically reasoned plan, or set of strategies, to present a lesson, unit or course. The process requires teachers to construct PCK, using their subject matter knowledge; general pedagogical knowledge; and knowledge of students and their educational context. There are four parts to transforming the content for teaching: preparation; representation; selection; and adaptation (Shulman, 1987)	Subject matter knowledge; general pedagogical knowledge; knowledge of student s and their educational context
i. Preparation	The process of 'preparation' involves "examining and critically interpreting materials of instruction" in order to detect errors and restructure the material into a form that is suitable for teaching (Shulman, 1987, p. 102).	Subject matter knowledge
ii. Representation	The process of representation involves deciding what multiple forms of "analogies, metaphors, examples, demonstration, simulations and the like" would best represent the ideas to students (Shulman, 1987, p. 103).	PCK, Subject matter knowledge
iii. Selection	The teacher draws on his or her repertoire of instructional modes to select an instructional form or strategy that would be appropriate in the teaching of the particular lesson.	PCK, general pedagogical knowledge and subject matter knowledge.
iv. Adaptation and tailoring	Involves "fitting the represented material to the characteristics of [student s]", characteristics such as; "aspects of [student] ability, gender, language, culture, motivations, or prior knowledge and skills" (Shulman, 1987, p. 103	PCK, in particular, knowledge of students and their educational contexts.
3. Instruction	This refers to "observable forms of classroom teaching", in which the prospective plan is enacted (Shulman, 1987, p. 101). It includes classroom management, presentation of content, interaction with students, and assigning of work. (Shulman, 1987).	General pedagogical knowledge and PCK
4. Evaluation	The teacher checks for student understanding while teaching interactively. The teacher requires a "deep grasp of both the material taught and the process of learning" (Shulman (1987, p.106) to comprehend what a student understands.	PCK
5. Reflection	Reflection refers to "the set of processes through which a professional learns from experience" by reviewing the lesson in relation to the purpose that the teaching intended to achieve (Shulman (1987, p.106). The teacher "looks back at the teaching and learning that has occurred, and reconstructs, re-enacts, and/or recaptures the events, the emotions and the accomplishments" (Shulman, 1987, p. 106).	General pedagogical knowledge and PCK
6. New comprehension	As a result of thorough 'reasoned' teaching, the teacher comes to a "new comprehension" of the "purposes and of the subjects to be taught, and also of the [students] and of processes of pedagogy themselves" (Shulman, 1987, p.106).	

The model of pedagogical reasoning and action provides a process of reasoning about teaching and offers guidance on what to do with all the different knowledge categories that constitute the notion of PCK. Shulman (1986) argues that a teacher knows what is not understood by others, and can transform understanding, performance, skills or desired attitudes or values into pedagogical representations or actions. This suggests that the teacher has to understand what is to be learned and how it is going to be taught.

When teaching about water resources and management, the teacher needs to have a good understanding of the content that is to be learnt or taught (the big ideas), the purposes for teaching about Water Resources and their Management in Botswana (in relation to the national EE goals of AKASP) and how that content should be taught (EE specific strategies). Teaching has to culminate with new understanding by both the student and teacher. The teacher must "grasp, probe and understand the idea, see its many sides, shape and tailor it until it can be understood by the student" (Shulman, 2004, p. 234), thus PCK. Darling-Hammond and Baratz-Snowden (2005, p. 27) add that "the teacher should be able to observe, monitor, and assess children to gain accurate feedback about their learning and development". In this way, the teacher can carefully select specific ways to teach specific subject matter, know how to develop useful assessment tools for learning, evaluate student learning patterns and develop effective interventions and instructional strategies.

Thorough knowledge and understanding of lesson content is still necessary before one can present it to others in an understandable way (Morrow, 2007; Rusznyak, 2009). Insufficient understanding of the concept leads to the inability to design a process of learning that makes the content understandable to students (Rusznyak, 2009). It should be noted that comprehension on its own may not be sufficient, but the usefulness of knowledge lies in its value for judgement and action (Shulman, 2004, p. 234). The teacher therefore needs a good PCK that allows him/her to make these judgments and appropriate actions required for effective learning.

2.2.3. The construct of PCK

Pedagogical content knowledge (PCK) is included as a foundational knowledge base for teaching, and is described as an "amalgam" (Shulman, 1986) of content and pedagogical knowledge. This knowledge is different from the knowledge of a disciplinary expert and also from the general pedagogical knowledge shared by teachers across subjects. Shulman (1986) argues that effective teaching involves knowing the appropriate teaching approaches that fit the content, as well as knowing how elements of the content can be arranged for better teaching. PCK therefore emphasizes the understanding and representation of content knowledge for teaching purposes. It is the knowledge that teachers use in transforming content knowledge into forms that are comprehensible to students (Shulman, 1987). PCK is highly relevant to teaching practice, because it provides teachers with pedagogical reasoning based on specific content, students and context (Peng, 2013). PCK is therefore specific to particular subject content, for example, Water Resources and their Management in Botswana.

Therefore, PCK implies that if teachers are to "be effective practitioners, they need to possess an in-depth knowledge of how to represent the subject matter for students" (Firth & Winter, 2007, p. 599). They should identify ways of representing and formulating the subject so as to make it easily comprehensible to students. The quality of learning opportunities a teacher can organize is dependent on the teacher's conceptual understanding of what is to be taught, and his or her ability to make appropriate pedagogical choices. The interrelation between pedagogy and subject knowledge, and its implications for and in teaching, should therefore be recognised and considered in effective teaching, underlining the importance of Pedagogical Content Knowledge (PCK). This consists of "how particular aspects of subject matter are organized, adapted, and represented for instruction" (Ball & McDiarmid, 1990, p.1) and knowledge of what the students bring to the learning situation, that is, prior conceptions and misconceptions students are likely to have about a particular area and possible misapplications of pre-instructional knowledge (Shulman, 2004). Knowing if those preconceptions are misconceptions helps the teacher to select strategies most likely to be successful in restructuring the understanding of students and to address the students' difficulties (Shulman, 1986).

PCK has also been described as an amalgam of knowledge of subject matter, knowledge of students, general pedagogical knowledge and knowledge of context (Cochran et al, 2008). These domains together produce directly observable products in the classroom or 'manifestations'. These manifestations are "many, different and could include any visible products of teaching observable in the classroom such as; subject matter representations, curricular saliency, assessment and topic specific instructional strategies" (Rollnick et al, 2008, p. 1381). Barnett and Hodson (2001) also add that teachers draw on categories of pedagogical content knowledge, which include: "knowledge of student s' existing understanding, knowledge of effective teaching/learning strategies (effective for this particular content), alternative ways of representing the subject matter, and curricular saliency" (Barnett & Hodson, 2001, p. 433). Knowledge of curricular saliency enables a good teacher to judge matters, such as depth of treatment and contextualisation. The manifestations and the categories of PCK identified are in agreement with Geddis and Wood (1997), who argue that teaching is a transformation of SMK and identify different kinds of knowledge from which subject matter transformation emerges. These include:

- students' prior knowledge, including the preconceptions about a topic
- effective conceptual teaching strategies
- alternative representation of the subject matter
- importance of the topic to the overall curriculum – 'curricular saliency'.
- what makes the topic easy or difficult to understand? (Geddis & Wood, 1997, p. 612)

The categories of PCK as identified by Geddis and Wood (1997) are reverberated in Mavhunga's (2012) components of Topic Specific PCK (TSPCK) and Gess-Newsome (2015) model of teacher professional development and skill, which includes PCK. Mavhunga 2012, p. 33). Mavhunga (2012) and Gess-Newsome (2015) both argue that these different kinds of knowledge from which subject matter transformation emerges are considered when a specific topic is thought through. Gess-Newsome (2015) proposes the category Topic Specific Professional knowledge (TSPK), and argues that it makes clear that content for teaching occurs at topic level and not merely at disciplinary level. TSPK blends subject matter, pedagogy and context, and is

recognised as public knowledge or knowledge held by the profession (Gess–Newsome, 2015). This knowledge can have a normative function in terms of what we want teachers to know about topic and context-specific instruction. TSPK would be instrumental in designing professional development for teachers. TSPK is similar to the construct of Topic Specific PCK, a form of specialized content knowledge for teaching, regarded as the "understanding that provides the needed knowledge for Subject Matter Knowledge (SMK) transformation in a particular topic" and its conceptualization "… is premised on the understanding that transformation of SMK is one of the key elements in the establishment of PCK" (Mavhunga 2012, p. 33). They are both topic specific; make clear the content for teaching at topic level; blend subject matter, pedagogy and context and they are instrumental in the transformation of subject matter knowledge into teachable content. Topic Specific PCK (TSPCK) is essential for effective instruction and positively related to students' learning outcomes. In the study I therefore adapt the construct of Topic Specific PCK. I use these different kinds of knowledge to explore the teachers' TSPCK on the topic Water Resources and their Management.

The construct of PCK has evolved over time and different researchers describing PCK have come up with various categorizations and models. PCK, according to Kind (2009), originated as one of seven categories of 'teacher knowledge' proposed by Shulman (1986, 1987). These models combine components from Shulman's list of seven within PCK. Three of these propose PCK models that use components from Shulman's list, but develop the concept from theoretical perspectives (Kind, 2009, p. 176). The models by Cochran, deRuiter and King (1993) draw on principles from psychology; MaKinster and Veal (2011) place all knowledge components into a taxonomy; and Banks, Leach and Moon (2005) propose a new component, 'school knowledge', to subsume others (Kind, 2009, p. 176). There is much that has been written about the importance of PCK as a foundational knowledge base for teaching, while few empirical investigations have been conducted into how different aspects of this knowledge are connected and may influence each other's growth (Henze, van Driel & Verloop, 2008). This study is opportune in that it explores teachers' beliefs about teaching and their environment, their understanding of the subject matter of an EE-oriented topic, the transformation of the subject

matter for teaching purposes, and the reasoning about the teaching of the topic. The study investigates the relationship between teacher beliefs, their knowledge and how these influence their PCK.

Capturing and portraying PCK

Although PCK is one of the foundations of teacher knowledge, capturing and clarifying PCK is a challenge. This is because PCK is not an easily identifiable aspect of practice, so there is a lack of tangible examples of PCK documented in the literature (Loughran, Mulhall & Berry, 2004). Although PCK may exist, it may not be easily recognised or articulated within one lesson or teaching experience. It may actually take some time for the PCK of a teacher to unfold (Loughran et al., 2004). Furthermore, PCK is multifaceted, therefore conceptualising and investigating it in practice has developed "through a variety of approaches" (Loughran et al., 2004, p. 372). There is some research on the development for tools to assess the quality of PCK (e.g. Abdullah & Halim, 2010; Park et al., 2011; Loughran, Berry & Mulhall, 2006). Although most of this research is in maths and science education, Abdullah and Halim (2010) developed a questionnaire to measure the level of teachers' Pedagogical Content Knowledge (PCK) in environmental education using the PCK components of subject matter knowledge, knowledge of teaching objectives and context, instructional and concept representation strategies, and knowledge of students as the areas of knowledge in PCK.

PCK of teachers can also be captured and portrayed using Pedagogical and Professional Experience Repertoires (PaP-eRs) and Content Representations (CoRes) (Loughran et al., 2004; Rollnick et al., 2008). CoRes highlight teachers' understanding of the characteristics of content. CoRes display and discuss the teachers' understanding of certain aspects of PCK, such as: a summary of the main ideas; knowledge of alternative conceptions; insightful ways, assessing for understanding; known areas of confusion; effective sequencing and important approaches to the framing of ideas (Loughran et al., 2004). The Content Representation (CoRe) template, as a research tool, helps access teachers' understanding of the content, as well as representing this knowledge.

Pap-eRs are used to illustrate how knowledge might inform effective classroom practice. They provide "a window into teaching and learning situations wherein it is the content that shapes the pedagogy" (Loughran et al., 2004, p. 377). The PaP-eRs are about teaching that content in that context and help to illustrate aspects of PCK in action. PaP-eRs emerge from teachers' actual practice and hinge on a particular content area (Loughran et al., 2004). It is important to note that single PaP-eRs cannot illustrate the complexity of knowledge around a particular content. Instead, a collection attached to areas of CoRe is important in highlighting different blends expressive of PCK (Loughran et al., 2004).

2.3. Theoretical framework for the study

This section describes how I develop the theoretical framework of the study, how it will be used and the framework (see Fig. 2.3) that will guide and inform the research. The study will look at effective teaching and learning with the aid of the modified model for PCK in EE.

2.3.1. A framework for PCK in EE

An adapted framework of PCK is proposed and used to analyse the effectiveness of EE in Botswana schools. The framework is an adaptation of the Gess-Newsome (2015) model of teacher professional development and skill, including PCK. It encompasses the main components of my study and my research questions which focus on teacher professional knowledge bases, teacher beliefs about teaching, content knowledge and pedagogical content knowledge, particularly for the topic Water Resources and their Management in Botswana. This framework draws from the notion that teacher knowledge bases are useful in understanding the education and performance of the teachers, that is, those competencies are exceptional and essential for teaching (Shulman, 1986; Darling-Hammond & Baratz-Snowden, 2005). Literature has also shown that beliefs and teacher professional knowledge bases, mainly subject matter knowledge, are important in investigating PCK, hence I consider them in constructing my theoretical framework.

The framework includes the goals of EE, as well as the teaching methods, in the integration of EE. Furthermore, the framework includes the components of action, experience, and concern as per Palmer (1998), and components in Environmental education *about, in* and *for* the environment (embedded in national goals for EE in Botswana, namely awareness, knowledge, attitudes, skills and participation (AKASP). There are few empirical studies that explore how PCK relates to both teacher beliefs and content knowledge, especially in EE, so my study should serve to fill a gap. It investigates teachers' beliefs about the environment and beliefs about effective teaching of EE, teachers' understanding of the topic Water Resources and their Management in Botswana, as well as examines how teachers transform CK on Water Resources and their Management in Botswana. The study therefore explores teachers' ability to represent and articulate their PCK in EE.

The adapted framework maintains that Teacher Professional Knowledge Bases (TPKB) inform and are informed by Topic Specific Pedagogical Content Knowledge (TSPCK), hence the two-way arrows between the two to show the interrelationship. TSPCK is an understanding of content that provides the needed knowledge for Subject Matter Knowledge (SMK) transformation in a particular topic (Mavhunga, 2012).

The framework assumes that teacher beliefs about the environment and about teaching influence their understanding about teaching, especially the teaching of EE topics. Thus I consider these beliefs underpinning factors influencing the TSPCK and vice versa (Magnusson et al., 1999; Davidowitz & Rollnick, 2011). They also act as amplifiers and filters to teacher learning and mediate teacher actions, so the relationship is shown by two-way arrows between the teacher beliefs and classroom practice. PCK is included under the classroom context since that is where it can be examined.

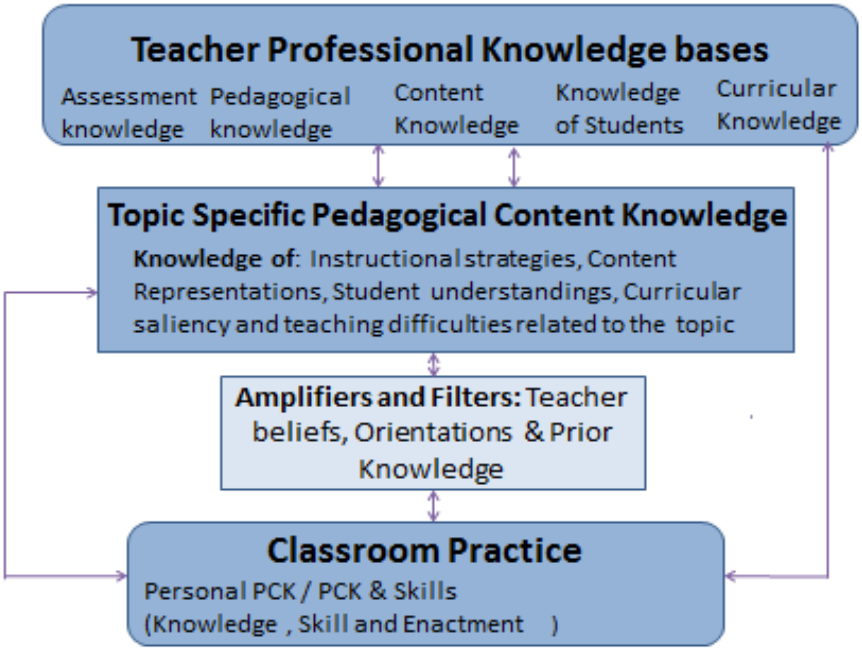


Fig 2.3. Adapted framework for PCK

The illustrative adapted framework for PCK in EE as shown in Fig. 2.3 includes: Teacher Professional Knowledge Bases, Topic Specific Pedagogical Content Knowledge, teacher beliefs as amplifiers and filters and classroom practice (Personal PCK and PCK and Skills). I use it as an organising framework for the study, that is, conceptualisation, data collection and tools and the analysis of data. Below I describe the components of the framework and explain how I characterise each one of them in my study.

Teacher Professional Knowledge Bases (TPKB)

This entails knowledge required for practice; it is not content specific, and hence generic and applicable across all teaching disciplines (Gess-Newsome, 2015). Thus this knowledge is not necessarily specific to Social Studies and EE but relevant across all the subject areas. It includes:

- Assessment knowledge – knowledge of the design and use of formative and summative assessments and how to use results from those assessments to design or modify instruction (Gess-Newsome, 2015).

- Pedagogical knowledge – principles and strategies for classroom management and student engagement, e.g. questioning techniques, instructional strategies to support differentiation based on the student needs, or how to design lesson plans (Shulman, 1987; Gess-Newsome, 2015).
- Content Knowledge – academic-related knowledge that includes structures, rules and practices used to generate knowledge in the field of EE. These are the disciplinary core ideas and the recognition of crosscutting concepts (Shulman, 1987; Gess-Newsome, 2015).
- Knowledge of students – knowledge of how students learn, their linguistic abilities, interests and aspirations (cognitive and physical development), their learning styles and preferences**.** Also appreciation of students' prior knowledge, student conceptions or preconceptions, understanding their differences for instructional modification and differentiation and knowledge on how to capitalise on available assets to improve instruction (Shulman, 1987; Gess-Newsome, 2015)
- Curricular knowledge – the goals of the curriculum, curriculum structures, the role of a scope and sequence and the ability to assess a curriculum for coherence and articulation (Gess-Newsome, 2015).

Topic Specific Pedagogical Content Knowledge (TSPCK)

In this study, one of the research questions requires that I explore teachers' understanding of Water Resources and their Management in Botswana and how this knowledge is transformed into teachable content, hence the inclusion of Topic Specific Pedagogical Content Knowledge. TSPCK is topic-specific and here it is applicable particularly to the topic Water Resources and their Management which is the focus for my study. Topic Specific Pedagogical Content Knowledge includes knowledge of:

- Instructional strategies - these are mainly the best teaching approaches in a given context or for a given topic. In my study, these would be the best teaching strategies for the topic Water Resources and their Management in Botswana. They should be informed by the knowledge of applicable learning theories on teaching and learning in EE (learning *in, about and for* the environment, Palmer, 1998) and the goals of EE (AKASP). Water is an important resource that is central to all human activities, hence teaching and learning should go beyond the acquisition of skills and knowledge; there should also develop a sense of responsibility and active student participation in the resolution of environmental problems (Tilbury, 1995). Suitable strategies would include inquiry-based, outdoor learning and problem-based learning. They provide students with the opportunities for real-life learning (Walker, 1997; Barry, 2006) about water and water resources in their environment. This allows them to be more involved in their environmental water issues; they are encouraged to participate and act to improve and safeguard water and water sources around them.

- Content representations – entails selecting and using varied illustrations like diagrams, pictures, simulations, tables and oral/written presentations to navigate the topic. This is part of the ability to understand student background experiences and misconceptions, and relate them to the learning of the topic. Content representations can be shown in the way teachers think about the knowledge needed to teach a particular topic at a given grade. For example, in this study, content representations would be shown in the development and agreement on the big ideas for the topic Water Resources and their Management in Botswana and construct a representation of their collective TSPCK on the topic. The teacher could use tables to depict how much water the students use for different activities in their families, water sources and their capacities, water demand areas and pictures illustrating the different ways of being water-wise at home.

- Student understandings - these entail understanding of students' prior knowledge or misconceptions about the topic and knowing how to integrate crosscutting concepts within the topic on water. That is, the teacher needs to know what the students already know about the topic Water Resources and their Management from previous grades, and their

different conceptions or misconceptions about the topic. Having different conceptions mean that the students will learn different things from the same topic and apply their understanding in different ways. If the teacher is aware of this, he/she can design learning activities that will enable students to process and construct relations between the elements of information in the idea being learnt (Cakir, 2008).

- Curricular saliency – is established in the importance, depth and contextualisation of the topic. For WR&M, this would include the big ideas on the topic, why the topic is important and sequencing, that is, knowledge of what to begin with and what to leave out for later when teaching the topic.

Teacher amplifiers and filters

- Teacher beliefs and orientations - beliefs can be powerful mechanisms supporting the formation of constructive personal theories, which, in turn, inform practice (Magnusson et al. 1999; Moseley & Utley, 2008). All teachers have personally constructed beliefs about teaching and, as teachers engage in instruction, these beliefs expand in their epistemological orientation. Beliefs reveal how teachers view knowledge and learning, that is, beliefs about what should be taught, how it should be taught and why it should be taught. These beliefs can be for problem-solving, or to promote social justice (Gess-Newsome, 2015) and could be teacher-, student-, learning- or knowledge-centred. These beliefs suggest how teachers may conduct their classroom practice (Luft & Roehrig, 2007, p. 47) - their preferred instructional strategies. Teachers' environmental orientations may also influence the way they approach topics on the environment (in this case, Water Resources and Management), depending on whether their environmental orientations are ecocentric or technocentric.

- Prior knowledge - teacher knowledge influences learning and acts as an amplifier or filter between knowledge and practice. For example, novice teachers apply new knowledge and skills to instructional planning differently to expert teachers. This is because teachers with highly structured and deep content-knowledge have the potential to profit

differently from content-deepening experiences than teachers with limited knowledge or misconceptions (Gess-Newsome, 1999). Thus, a teacher with a deeper content knowledge on water resources management is more able to develop effective learning experiences for their students. The content knowledge on WR&M includes knowledge of the sub-concepts on water resources and management, that is, quantity, quality and management, as well as the big ideas that emanate from the sub-concepts.

Classroom practice

This is the location of PCK. PCK is personal knowledge; it is context specific and includes the teaching of a particular topic in a particular way for a particular purpose to particular students; it is not generalized but lives in a specific experience (Shulman, 1987; Gess-Newsome & Lederman, 1999; Gess-Newsome, 1999/ 2015). In my study, I characterise personal PCK as the **knowledge** of, **reasoning** behind, and **planning** for teaching a particular **topic** (Water Resources and Management) in a particular **way** (teaching and learning about water, using inquiry- and problem-based instructional strategies) for a particular **purpose** (sustainable use of water and water resources) to particular **students (**Form 1 Junior secondary students**)** for enhanced **student outcomes** (water-wise practices, environmental awareness and action). PCK emphasizes the understanding and representation of content knowledge for teaching purposes, thus it provides teachers with pedagogical reasoning (Shulman, 1987), based on specific content and specific students and context (Peng, 2013).

PCK in the study will be displayed in the application of knowledge to teaching of the topic Water Resources and their Management by individual teachers and can be found in the instructional plans and CoRes that the teachers create and in the reasons behind their instructional decisions (Gess-Newsome, 2015). It is the knowledge that teachers use in transforming content-knowledge on Water Resources and their Management into forms that are comprehensible to students (Shulman, 1987).

2.4. Summary

In this chapter, I have described research related to the teaching of EE-oriented topics in junior secondary schools. I defined environmental education and highlighted the methods of teaching strategies in the integration of EE, that is, *about, in* and *for* the environment. I further explored studies on EE teaching to establish the issues and challenges in EE, and the trends in research on EE teaching. This exercise was to generate reasonable expectations for success in the intended goal of the study. Since one of the research questions of the study seeks to examine teachers' understanding of content knowledge on Water Resources and their Management in Botswana and how it transforms the SMK into teachable content, I explored literature on teachers' knowledge. I particularly focused on the relationship between CK and PCK for effective teaching. Literature has shown that a good understanding of CK precedes the ability to teach effectively (Darling-Hammond & Baratz-Snowden, 2005; Shulman, 1986/7; Morrow, 2007). I explored PCK, particularly the process of reasoning and pedagogical action which forms part of the pedagogical transformation process. This helped inform my data collection and analysis, particularly for the research question on the transformation of CK into teachable content.

I then suggested a framework that I use to explore teachers' PCK on the teaching of the topic Water Resources and their Management in Botswana, an EE-oriented topic. In the proposed framework, I included teacher Professional Knowledge Bases, Topic Specific Pedagogical Content Knowledge, Beliefs and Classroom Practice. The included components of the framework are representative of the main characteristics of my research questions. I describe how I use the model to investigate teachers' representation and articulation of their PCK in EE. This proposed framework influences the research design through which the construct of PCK is explored: the data collection, the interaction with the participants and the analysis of the data collected in the study. In the next chapter, chapter 3, I present the research design for the study.

CHAPTER 3: RESEARCH DESIGN & TOOLS OF ANALYSIS

3.0. Introduction and overview

In this chapter, I present a justification for the research design of the study, the instruments used for data collection and a description of the ways in which data was collected. I relate the methodology to the theoretical framework and my research questions. I describe the methods I used in the study, the basis for using such methods, the data collection process, the selection of participants, the instruments used to gather data, their development and piloting, and issues of ethics, reliability and validity.

3.1. Research design

Educational researchers conduct their studies based on alternative ways of conceiving social reality: the objectivist and subjectivist views. These two contrasting perspectives are reinforced by a set of explicit and implicit assumptions about social reality which can be further broken down into four interrelated elements: ontology, epistemology, human nature and methodology (Cohen et al., 2000). The two perspectives have profound implications on decisions made about the problem, the questions, the characterisation of the participants, the methodological concerns, the data collected and how it will be processed (Cohen & Manion, 1994). It is therefore important for the researcher to be explicit about their own ontological and epistemological assumptions (Cohen & Manion, 1994; Opie, 2004). The objectivists perceive that the world exists and is knowable as it is (Cohen & Manion, 1994, p.10). They regard "social phenomena and their meanings" as having an "existence that is independent of social actors" (Bryman, 2006). This is typical of the quantitative research which assesses the causes that influence outcome and places more emphasis on scientific method, statistical analysis and generalisable findings. Subjectivists argue that the world exists but different people construe it in different ways (Cohen & Manion, 1994, p.10). This perspective is characteristic of qualitative research where realities are constructed and focus is on gaining understanding of individuals through interactions and experiences (Cohen & Manion, 1994). Qualitative research is informed by the interpretive research paradigm which stresses inductive thinking, an exploration of

issues and settings in depth, building of models and theory, and the use of descriptive materials from different types of data collection and analysis (Cohen & Manion, 1994; Creswell, 2009).

My study explored Botswana Social Studies teachers' understandings and conceptions of water resources and management, and how the teachers transformed underlying subject-matter knowledge of the topic into teachable content knowledge. Furthermore, the study, through interaction with teachers, sought to contribute to teacher development in EE. The study is therefore qualitative. This approach enables the researcher to understand human experience better, and, in particular, how people construct meaning, and what those meanings are (Bogdan & Bickel, 1992; Merriam, 1998). The advantages of qualitative research are such that the "details and comprehensiveness a researcher cannot predetermine are apprehended" (Nartgun, 2007, p. 600). Because teaching is complex and teachers' PCK is not a construct that is easily detectable, a qualitative research method was adopted in this study to collect more comprehensive data and for in-depth understanding of the teachers' perceptions about the topic Water Resources and their Management in Botswana and its teaching. The study adopts the qualitative research in the form of a case study approach to inquiry. The following section elaborates on my choice of case study research.

3.1.1. Case study research

A case study is a study that "examines a bounded system or a case, employing multiple sources of data found in the setting. This case may be a program, event, an activity or a set of individuals bound in time and place" (McMillan & Schumacher, 2006, p. 26). This study is a case study, as it is confined to the teaching and learning of the topic Water Resources and their Management in Botswana and limited to an identified group of Social Studies teachers. A case study aims for an "understanding of educational action as well as enriching the thinking and discourse of educators either by the development of educational theory or by refinement of prudence through the systematic and reflective documentation of evidence" (Bassey, 1999, p. 28). The objective was to explore how the group of Social Studies teachers transform their

understanding and knowledge about EE into teaching about, in and for environmental ideals, hence the decision to use the case study research.

In this approach, the researcher usually observes the characteristics of the unit to be studied so as to probe and analyse intensively the different phenomena that constitute the development of the unit (Cohen & Manion, 1994). In this study, I explored teacher beliefs, teacher professional knowledge and pedagogical thinking. These were explored through an interaction with the teachers who were in an in-service course at the University of Botswana upgrading to degree level and specialising in Social Studies using different identified data collection tools.

Case study research is powerful in that it describes effects in real contexts and recognises that context is a determinant of both cause and effect. Furthermore, case studies can adopt a collective, interpretive or exploratory case study design (Cohen & Manion, 1994; Merriam, 1998; McMillan & Schumacher, 2006). Yin (2009) asserts that exploratory case study research is suitable for investigating research questions of a "how" or "why" nature, mostly where the researcher has little control over the actions of those involved in the study and where the focus is on contemporary events. I therefore used this design to investigate how teacher beliefs influenced their teaching, as well as how they transformed their knowledge of Water Resources and their Management into teachable content.

3.2. Participant selection procedure

Since the intention of my study was to explore teachers' beliefs, CK and PCK in Water Resources and their Management, the 'case' had to consist of teachers who are or have been in practice. Interaction with these teachers created a rich source of relevant data (McMillan & Schumacher, 2006). I therefore chose participants that included a group of teachers teaching Social Studies in Junior Secondary schools in Botswana and those enrolled for a BEd course at the University of Botswana. The teachers in the Junior Secondary schools were sourced from the Junior Secondary schools in and around Gaborone. The data from the teachers in the Junior Secondary schools was mainly used as baseline data.

The University of Botswana has a programme for Junior Secondary School teachers who are upgrading from a diploma in secondary education to degree level. This group is ideal because its members are experienced Social Studies teachers. Unlike novice teachers, they would have a more developed PCK and are at a stage where they are more innovative and can adopt stable, continuous innovative approaches to teaching (Berliner, 1992). These teachers were also doing a course on EE methodology, so part of the research was to explore their understanding of the topic Water Resources and their Management and how they approached the topic in their teaching. Permission was requested from both the University of Botswana and the Botswana Ministry of Education and Skills Development to include these teachers as possible respondents by writing letters to the respective authorities (see appendix A).

Convenience sampling was used to acquire respondents and participants for the study. This entails selecting a group of participants on the basis of their accessibility or expediency (McMillan & Schumacher, 2006, p. 125). The most available individuals may be chosen until the required sample is complete (Opie, 2004). This type of sampling is less costly and time consuming, easy to administer and ensures high participation. Although the convenience sample may be less representative and its results difficult to generalise to other subjects, generalisation is possible to similar subjects (McMillan & Schumacher, 2006).

The study comprised of two groups of teachers (see Table 3.1 below). The first group comprised twenty-one Social Studies teachers from Junior Secondary schools in and around Gaborone and also from Kanye. The second one was made up of five Social Studies teachers who were at the University of Botswana upgrading to degree level (B.Ed. Secondary). For the teachers at the Junior Secondary schools, I use codes to represent the school and the respondents. For example, GB represents the school while 1 represents the respondents (see Table 3.1). These teachers from the Junior Secondary schools provided baseline data for the research questions that sought to explore teachers' beliefs about teaching, particularly the teaching of EE, as well as the understanding of Water Resources and their Management in Botswana.

Table 3.1. Summary of biographic data for the respondents in the study

Respondents		Qualification	From (yr.)	To (yr.)	Subject/s specialisation	Teaching experience (Years)	EE teaching methods	Ecology & Environmental studies
BASELINE PARTICIPANTS	GB1	DSE	?	?	English & S/studies	1	NO	NO
	GMT1	DSE	1998	2000	Setswana & S/studies	11	NO	NO
	GM1	DSE	1999	2001	S/studies	8	NO	NO
	GM2	DSE	1994	1996	Physical Education & S/studies	16	NO	NO
	GM3	BA Humanities & PGDE	1998	2000	English& History	7	NO	NO
	GM4	DSE	1995	1997	S/studies	15	NO	NO
	GN1	BA Humanities & PGDE	2008	2011	History & Environmental science	1	NO	YES
	GN2	B.Ed. Counselling & DSE	2007 / 1992	2010 / 1994	S/studies / Guidance & counselling	14	YES	NO
	GN3	BA Humanities & PGDE	1998	2000	English & History	78	NO	NO
	GN4	DSE	?	?	Moral Education/ Social Studies	10	NO	NO
	KM1	DSE	2000	2002	S/studies	9	NO	YES
	KM2	BA Humanities & PGDE	1995	2000	English& History	11	NO	NO
	KN1	B.Ed. secondary	2009	2011	S/studies & African languages	15	YES	YES
	KN2	BA Humanities & PGDE	1997	2002	History / Environmental science	11	NO	YES
	MM1	DSE	1999	2001	S/studies / Computer studies	11	NO	YES
	TT2	BA Humanities & PGDE	1994	1999	Environmental science	13	YES	YES
	TT3	B.Ed. secondary	2004	2007	History & Development studies	3	NO	NO
	GB2	DSE	?	?	S/studies	12	YES	NO
	GB3	DSE	1994	1996	Religious Education / S/studies	15	NO	NO
	TM1	DSE	1995	1997	S/studies	15	YES	YES
	TM2	DSE	1993	1995	Religious Education / S/studies	13	YES	NO
CASE STUDY	**Boitshepo**	DSE	1995	1997	Social Studies	13 years	NONE	NONE
	Felicia	DSE	1991	1993	Social Studies	20 years	NONE	NONE
	Irene	DSE	1995	1997	Social Studies / English	14 years	NONE	NONE
	Kagiso	DSE	1995	1997	Social Studies	14 years	NONE	NONE
	Naledi	DSE	1994	1996	Social Studies / Setswana	15 years	YES	YES

The data from the five in-service social studies teachers who were at the University of Botswana upgrading to degree level (B.Ed. Secondary) addressed all the research questions in the study, that is, teacher beliefs and the understanding of Water Resources and their Management in Botswana.

3.2.1. Gaining access to participants

I obtained permission in the form of letters to pursue data collection from the following authorities: the Ministry of Education and Skills development, the University of Botswana, Heads/Deputy Heads of schools, senior humanities teachers, Social Studies coordinators and teachers in the schools selected. I then met with the potential respondents at the identified schools and at the University, had briefing sessions with them as to what the study entailed and invited them to participate in my study. I thereafter made arrangements for meetings with those that had agreed to participate. Arrangements were also made with the lecturer for the EE methodology course to meet with the participants for the briefing; an invitation to the study was issued and scheduling arrangements for the interactions made. A verbal agreement was also reached with the EE methodology course lecturer at the University of Botswana to allow me to work with the B.Ed. students in his course, as part of the interaction would form some of his course requirements, such as lesson planning.

3.3. Data collection procedure and tools

The study adopted several data collection strategies to investigate how teachers used and applied their understanding of the teaching of Water Resources and their Management in Botswana. The data collection was done through the administration of a beliefs tool and a questionnaire to the baseline participants, and interaction with the teachers using a beliefs tool, a questionnaire, mind maps, CoRe templates, document analysis, textbook analysis, lesson plans and follow-up teacher interviews. Table 3.2 lists the purposes for data collection, the components explored, the tools used and the participants to whom the tools were administered.

Table 3.2. Illustration of the purposes, tools and the participants used for data collection

Purposes for data collection	Data Collection strategy used	Participants
To investigate beliefs		
• *About teaching*	Questionnaire, Teacher beliefs interview, Metaphors	Baseline Participants and Case study participants
• *About the environment*	Survey	Baseline Participants and Case study participants
To investigate knowledge on environment and water resources and management	Questionnaire Mind Maps	Baseline Participants and Case study participants Case study participants
To investigate PCK	Content Representation template Lesson plan Rationale Textbook analysis Interview	Case study participants

3.3.1. Beliefs tool

To develop the beliefs tool, I adapted questions from the Teacher Belief Interview (TBI) by Luft and Roehrig (2007). Although the TBI was an interview that sought to unearth teachers' beliefs about science teaching, I converted it into a questionnaire and made some modifications by rephrasing the questions to suit the context of the study. The TBI was used because of its qualitative nature and tested credibility. The four questions adapted from the TBI addressed the subject-specific beliefs. I also added other questions that considered the teachers' general beliefs about teaching, for example, their reasons for choosing teaching as a career; what they love about their job; their challenges; what they consider as the most important qualities for an effective teacher.

The beliefs tool was administered to all 26 participants in the study. It was designed to collect data that would help answer research sub question one, that sought to unearth teachers' beliefs about teaching. The tool consisted of nine questions (see appendix B); four examined general beliefs on teaching and five specifically targeted the teaching of the subject as per the

focus of the study. Teachers have different beliefs and these are particularly influenced by their goals for teaching. These goals could be for attitude and behavioural change, real world connections, transmitting facts or knowledge, learning, humanistic, improvement for pedagogy, social reform/good citizenship or knowledge acquisition (Magnusson et al, 1999). Beliefs could either be general or discipline-specific. The beliefs tool was developed to explore both the general and subject-specific beliefs about teaching.

Initially all the questions from the TBI had been incorporated into the beliefs tool but were altered after piloting. For purposes of piloting, 7 Social Studies teachers from three Junior Secondary schools that were excluded from the sample that constituted the research group, were asked to respond to the tool. Their responses for some of the questions yielded the same responses while others were not adequately answered. For example, the pilot group pointed out that they had difficulty in distinguishing between the questions on how they know when their students understand what they are teaching and knowing when learning is occurring in their classrooms, so their answers were either the same for both questions or one of the questions was left unanswered. It is possible that the teachers thought that the two questions asked the same thing, thus perceiving the questions to be duplicates. In the light of this feedback, some of the questions were left out, others rephrased and still others added.

In addition to the beliefs tool, I introduced a metaphor or simile, which required the teachers to identify and describe a job that was similar to teaching, and to explain their analogy. Metaphors have been used in several researches to explore teachers' conceptions about teaching and learning (Mahlios et al, 2010). The use of metaphors to explore teachers' conceptions about teaching and learning gives researchers an insight into the teachers' metaphorical analogies, helping to encapsulate what student teachers regard as the most salient aspects of being a teacher (Rusznyak & Walton, 2014). There were also 14 statements about effective teaching in the belief tool where the participants had to decide if they agreed or disagreed. If they disagreed, they had to state their reason(s). These participants were asked to rank the statements from most to least important. The beliefs tool also asked the teachers how they knew their students understood and how they learnt best. Although these statements are

general to teaching as a whole, they further help explore the teachers' perceptions as to what effective teaching entail. These perceptions influence the teachers' decisions and classroom practice.

3.3.2. Questionnaire

In qualitative research, questionnaires help measure certain characteristics or opinions of the respondents (May, 1993). The questionnaire in this study was a self-completion teacher questionnaire and had four parts (see Appendix C). Part I covered background or demographic data, that is: name, gender, qualifications, subject specialisation, subject/s taught, length of service and information on EE competencies, like workshops and courses on EE teaching methods and environmental issues. Part II explored the teachers' environmental views. The statements used to probe the teachers' views were adapted from Kearney (1999) who used them to check teachers' interests and attitudes on the environment. I used them to check teachers' viewpoints about the environment, using the different environmental views as discussed in the literature review and in chapter four. These environmental views include the technocentric (sometimes called anthropocentric) and the ecocentric, as described in Chapter 2, section 2.1.3.4.

Part III of the questionnaire explored the teachers' subject matter knowledge on environmental issues in their communities and on issues around water in Botswana. I identified patterns, themes, similarities and differences so as to help interpret the data. The questions for part III are an adaptation of the prompts for the CoRe Template by Loughran et al (2004) and also Kearny (1999) on establishing the teachers' perceived goals for teaching about EE. Part IV established teachers' PCK on the teaching of EE, that is, goals for teaching EE and teacher competencies needed in teaching of EE. The last part of the questionnaire establishes teacher knowledge of students' prior knowledge, curricular saliency, challenges of teaching the topic, knowledge of students' points of misunderstanding and misconceptions about the management and conservation of water resources.

The questions for the questionnaire were developed with the input of the feedback from the pilot. Data from questionnaires was also used in triangulation of data to enhance reliability. The questionnaire contained open-ended questions which gave the participants freedom to answer the questions as they interpreted them. It explored the teachers' subject matter knowledge, PCK and beliefs about the environment and teaching of EE topics: research questions one and three. The questionnaire was designed for all the 26 teachers to complete and was administered to both the baseline and the case study participants.

3.3.3. Teacher development activities with the case study participants

The interaction was conducted for the five Social Studies teachers registered at the University of Botswana for B.Ed. Secondary Education. The study sought to explore the Social Studies teachers' understanding about Water Resources and their Management in Botswana, as well as how they transformed their content knowledge into teachable content. This pertained to questions two and three of the study. A variety of activities were carried out to explore the teachers' content knowledge and their PCK. These activities included: mind mapping the topic Water Resources and Management; discussions of content using different sources, such as textbooks and articles on water in Botswana; exchanging thoughts on the different approaches to effectively teach a topic on Water Resources and Management; working together and individually to develop CoRes; individual and group lesson planning and presentation of planned lessons. Scheduled interactions with teachers were held at least twice weekly for a semester at the University of Botswana on the teaching of Water Resources and Management. The interaction commenced in January and continued until the end of April 2012.

Mind maps

Mind mapping is a practice which uses a non-linear approach to learning that encourages one to think and explore concepts using "… visuospatial relationships flowing from a central theme to peripheral branches which can be inter- related" (Zipp, 2011, p. 1). Teachers were asked to draw mind maps to help them conceptualise the topic Water Resources and Management. This exercise is aimed at collecting data for research sub question two, which explores teachers'

understanding of Water Resources and their Management in Botswana. At first, the teachers were allowed to individually brainstorm and come up with their own mind maps, revealing their organising principles (headings and subheadings/branches). Thereafter, I guided the teachers' mind mapping exercise by introducing three sub-concepts of water quantity, quality and management to help them explore and probe the topic Water Resources and their Management in a more conceptually organised way.

Developing Content Representations

A Content Representation (CoRe) template is a tool developed by Loughran et al. (2004) to capture and portray PCK. A CoRe displays and discusses the teachers' understanding of certain aspects of PCK that are most closely attached to a topic, that is, " … the key content ideas, known alternative conceptions, insightful ways of testing for understanding, known points of confusion, and ways of framing ideas to support student learning" (Loughran, Mulhall & Berry, 2008, p. 1305). CoRe, as a research tool, helps access teachers' understanding of the content, and is also a way of representing this knowledge. Although the CoRe was initially used for interviews and class observations by Loughran and his colleagues, I used it as an individual exercise where teachers explored four big ideas on Water Resources and their Management in Botswana.

During the pilot study, teachers had been asked to come up with their own big ideas to use in the CoRe. It became evident from all their CoRes that the big ideas they had used were the sub-headings for the topic Water Resources and their Management in Botswana, as per the main prescribed Social Studies textbooks for the Junior Secondary Social Studies syllabus. This was also common across all the respondents who constituted the focus group. The process of conceptualising big ideas is notably not an easy one (Wiggins & McTighe, 2006). As a result, the big ideas were obtained through team conceptualisation of the topic Water Resources and their Management between me and my supervisor who has expertise in environmental issues, research on water issues and management, collaboration with Geography teachers in the Botswana senior secondary schools and through analysis of the national curriculum documents.

I also attended a workshop organised by Rand Water at Delta Environmental Centre (Johannesburg, South Africa) on planning an investigative research project work on Water Management which also helped in the production of the big ideas. The big ideas were:

- Many human activities depend on access to water -
- Although water is a renewable resource, the amount of usable water is limited by how much can be stored -
- Water can be transported from one region to another -
- Water pollution can decrease its usability

The content for the different big ideas is provided in more detail in the Composite CoRe as illustrated in appendix D.

Lesson planning and presentation of planned lessons

The five participants from the focus group were requested to develop lesson plans using the Wits School of Education (WSOE) Rationale for Lesson design template (Rusznyak and Walton, 2011). This was meant to create a picture between knowledge and understanding against the respondents' thinking about effective planning and teaching of environmentally oriented topics as specified in research question two. The participants were asked to pick one of the 'big ideas' as the theme of their lesson design, and then choose a topic that suited the theme and use these to design a lesson plan using the WSOE Rationale for Lesson design template. The data from the lesson plans helped to further explore PCK by establishing the extent to which the teachers' plan is coherent with the purpose of the lesson, their interpretation and representation of the content, and the selection, adaptation and tailoring of their teaching strategies to suit the need of the students and the nature of the topic being taught. The respondent then later developed a group lesson plan which was presented to the rest of their colleagues in the EE methodology course (EEL 302) they were taking at the University of Botswana. This developed group lesson plan also constituted a certain percentage in the participant's continuous assessment for their course.

3.3.4. Interviews

An interview guide, with questions to lead the interview sessions, was prepared in relation to the responses that each of the respondents had provided in the beliefs tool, the questionnaire and the CoRe template (see Appendix D). Interviews are like discussions that researchers use to explore informants' experiences and interpretations (Hatch, 2002). In-depth interviews, also known as semi-structured interviews, were used. This kind of interview involves "repeated face to face encounters between the researcher and the informants" (Taylor & Bogdan, 1984, p. 77). It allows the researcher to lead the interview, have a time frame for interviewing and to record the interviews if so desired (Hatch, 2002). They are in-depth as they go deeply into the understanding of informants, allow for probing, are flexible and exploratory, and are like conversations (Merriam, 1998; Hatch, 2002). These characteristics therefore make interviews ideal for data collection purposes.

The interviews were conducted as follow-ups to the beliefs tool, the questionnaire and the CoRes. They further explored the teachers' SMK and PCK through the reflective discussions, as well as their beliefs on teaching about water resources and their management. The interviews also sought for clarification and evaluation of the interaction. The interviews were captured through audio recording, through making a record of nonverbal indicators and contextual influences not picked up on the recording, and by notes of key words and phrases important enough for purposes of future questioning or probing (Hatch, 2002). The interviews and the audio recordings were only used where participants had consented. The challenge with the interviews was that since most questions were open-ended, there was minimal control over the responses of the interviewees; there was need for "double attention" (Opdenakker, 2006). I therefore needed to listen carefully so as to understand the respondent and also ensure that the questions are answered with the intended detail. Transcribing the interviews was also time-consuming since some of the respondents switched between English and the vernacular language of Setswana, while some took longer explaining or putting their view across.

3.3.5. Document analysis

Documents are important data sources in qualitative research. Merriam (1998) asserts that these books, magazine and newspaper articles contain conversations, positions, arguments and descriptions that equate to the feedback obtained during fieldwork. The researcher has to use skill and intuition to find data relevant to their study and interpret it. In this study, I identified authentic documents on the relationship between teacher understanding and pedagogical choices, as well as those containing information on EE and/or ESD. These included documents, such as the Junior Secondary school Social Studies syllabus, Botswana EE Policy and Objectives, Botswana National Conservation Strategy, Social Studies textbooks, participants' lesson plans and CoRe templates. The documents were analysed and interpreted, and they helped establish teacher understanding of EE and PCK on water resources and management, and provide insight into current issues and practices.

I also did content analysis into extracts from the three main Social Studies textbooks for the Junior Secondary school level to explore PCK on Water Resources and their Management in Botswana. Qualitative content analysis of texts involves exploring the meanings underlying the texts and generating theory (Hsieh & Shannon, 2005). I looked particularly at the PCK components of curricular saliency, content representations, what is difficult to teach, student prior knowledge and conceptual teaching strategies. I also explored the content on water resources and management, the order in which the content was presented, connections in the content presented in the texts, and the most emphasized teaching strategies and activities as presented in the analysed textbooks. I then examined the EE methodology course outline for aspects of PCK that the respondents in the focus group would have been exposed to. Fig 3.1 illustrates a summary of the data collection tools and procedure.

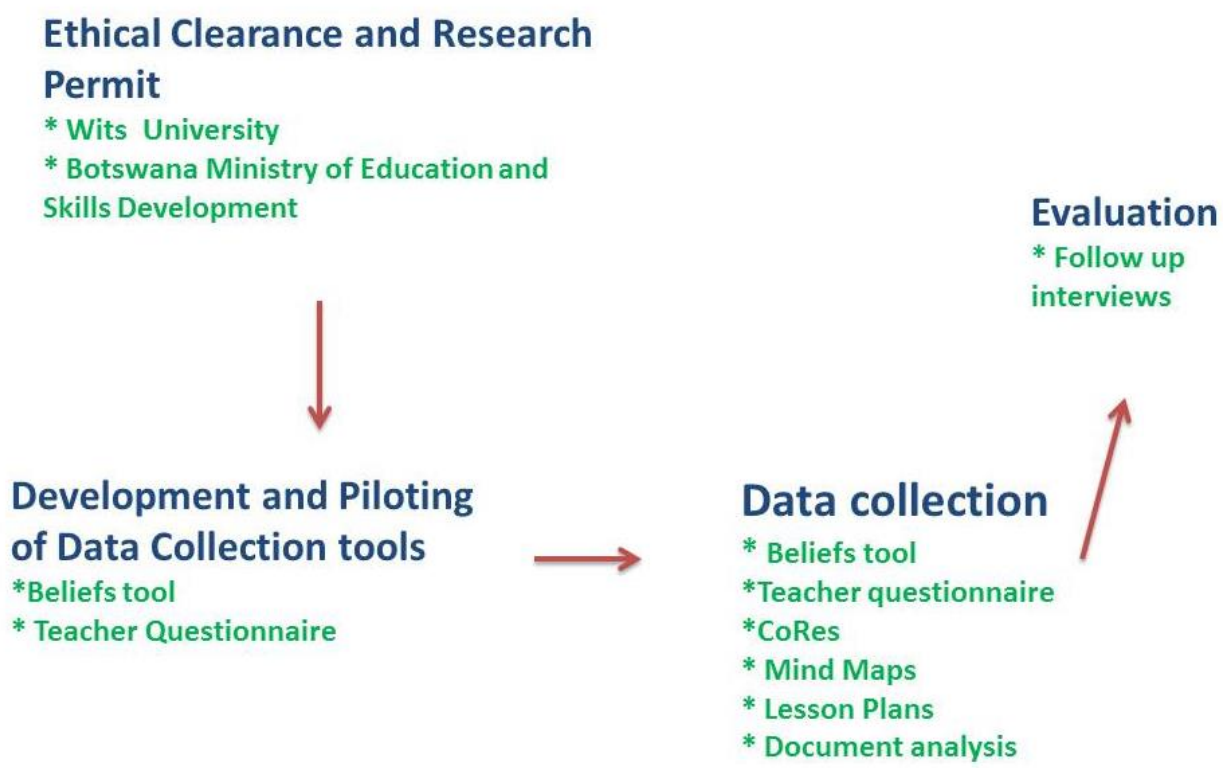


Fig 3.1. Summary of data collection and analysis procedures

3.4. Trustworthiness

This section discusses how trustworthiness was established in the study. Trustworthiness, according to Lincoln and Guba, (1985), is based on how the researcher persuades their audience "that the findings of an inquiry are worth paying attention to, worth taking account of? What arguments can be mounted, what criteria invoked, what questions asked, that would be persuasive on this issue" (p.290). It ensures that the "design of research provides credible conclusions, whether the evidence which the research offers can bear the weight of the interpretation that is put on it" (Bell, 2005, p. 118). Lincoln and Guba (1985) suggest that trustworthiness in qualitative research can be established in terms of credibility, dependability, transferability and conformability. Credibility and dependability of the instrument stems

directly from the legitimacy and trustworthiness of the results it obtains, whether it measures or describes what it is supposed to measure or describe.

Credibility

In qualitative research, credibility and "rigor derives from the researcher's presence, the nature of the interaction between the researcher and the participants, the triangulation of data, interpretation of perceptions and rich thick description" (Merriam, 1998, p. 151). Credibility in this study was improved through piloting of the tools, peer validation and the use of more than one data collection tool/method, or triangulation. This involved using multiple sources of data, or multiple methods, to confirm the findings (Merriam, 1998; Bell, 2005). Triangulation helps improve "… the probability that findings and interpretations will be found credible" (Lincoln and Guba, 1985, p. 305). Furthermore, it enables the researcher to see the same thing from different perspectives and cross-references the findings of one method with those of another. In this research, questionnaires, a beliefs tool, CoRe templates, lesson plans, audio recording in interviews and document analysis were used to complement each other. The use of data from multiple sources enabled each data set to be revisited several times during data analysis to ensure accuracy of interpretation and consistency with the theory upon which the study is based (PCK).

Credibility was also enhanced through consistent interpretation, classification and reduction, as well as identification of themes that relate to PCK and the influence of subject matter knowledge on pedagogy for effective teaching. This helped to increase the credibility of the research findings. Navigating the data and the theory supporting the research also enabled the consistency and accuracy of findings to be checked, as well as identifying disconfirming evidence (Miles & Huberman, 1994). In the case of mismatches, conflicts and different viewpoints from data accounts, I had the help of colleagues who helped me critically examine the data and make sense of any mismatches that came about, using the rubrics that I developed. I also clearly clarified my assumptions, worldview and theoretical orientation at the beginning of the study to enhance credibility (Merriam 1998). For purposes of this research, the

assumptions and theoretical orientation are clearly described in the literature review and the theoretical framework.

Dependability

Dependability refers to the degree to which different researchers using the same methods in the same setting and context would get similar results if the study is repeated. Creswell (2013) argues that dependability can be enhanced through detailed field notes, good recording of the interviews, transcription of interviews and the cross-checking of codes by different researchers. Dependability, in my study, resulted from pilot testing the data collection tools before using them. Data was also transcribed before analysis to help to minimise bias and also improve accuracy and reliability of the data.

Conformability

Conformability refers to the degree to which the findings of a research study are created by the participants and not by the researcher's bias, motivation or interest (Denscombe, 2007). A data trail was used in my study to enhance conformability. This ascertains whether the findings are grounded in the data and whether conclusions based on the data are logical (Cutcliffe & McKenna, 2004). I looked carefully at the "analytical techniques used, appropriateness of category labels, quality of interpretations and make an assessment of the degree and incidence of inquirer bias" (Cutcliffe & McKenna, 2004). Based on this information, an independent assessment of the study can be made and the findings reported 'confirmed'.

For example, I compiled a CoRe for each teacher using the data from the questionnaire administered, their initial responses to the CoRe, the lesson plans and the responses from the follow-up interviews used for clarification on some of the responses from the questionnaire and the CoRe. I reallocated ideas to appropriate categories so as to come up with the best possible CoRe for each teacher. The original CoRes, lesson plans and questionnaires developed by the respondents are attached (see samples in appendix E, F, G, H, I, P and Q) to show what the respondents initially had as their responses.

Transferability

Transferability relates to the extent to which the findings of one study can be applied to other situations (Merriam, 1998). The findings of a qualitative project are specific to a small number of particular environments and individuals, hence "it is impossible to demonstrate that the findings and conclusions are applicable to other situations and populations" (Shenton, 2004). My study is a case study, hence transferability is limited. A case study cannot offer transferability unless the reader recognises the applicability of results to his/her situation. Nevertheless, Denscombe (2007) and Stake (2008) argue that despite the uniqueness of each case, they are examples within a larger group, so transferability should not be easily dismissed. Lincoln and Guba (1985) suggest that it is the responsibility of the investigator to ensure that sufficient contextual information about the site of study is provided to enable the reader to make such transfer. With this in mind, I provided background data on the study to establish the context of the study, as well as a detailed description of the literature and themes central to the study to allow for comparisons to be made by the reader. The use of rich, thick descriptions in the analysis of data also assists the reader's ability to "determine how closely their situations match the research situation" (Merriam, 1998, p. 211). The reader will get a sense of shared experience.

3.5. Data analysis procedures

Data analysis is described by Hatch (2002) as a systematic search for meaning, processing data so that it can be communicated to others. This process involves "organizing and interrogating data in ways that allow researchers to see patterns, identify themes, discover relationships, develop explanations, and make interpretations, mount critiques, or generate theories" (Hatch, p. 149). Unlike quantitative data analysis, in qualitative analysis there are no clearly laid-down procedures for analysing data, no right or wrong way to do it (Merriam, 1998; Hatch, 2002). The complexity of analysing qualitative data is compounded by the form of the data which is mostly descriptions or narratives of objects, events or processes. Making sense of such data is the challenge of qualitative data analysis.

Even though no clear plan for analysing qualitative data can be suggested, various ways of making sense of it include a deductive process of categorizing data and identifying relationships (Hatch, 2002; McMillan & Schumacher, 2006; Pope et al, 2002). Deductive analysis is undertaken with a theoretical framework as background (Pope et al, 2002). The study focuses on a teacher basis for the influence of understanding on pedagogical choices, so the analysis will be somewhat theoretically sensitive. Theoretical sensitivity refers to the ability "to recognize what is important in the data and give it meaning" (Hitchcock & Hughes, 1995, p. 298). In this study, the model for PCK (Davidowitz and Rollnick, 2010) and the model for teaching and learning about the environment (Palmer, 1998) were adapted to develop a modified model for PCK in EE. This model will be continually referred to so as to inform the data analysis. Interaction between the incoming data and theoretical ideas from literature will facilitate appropriate coding and categorising of the data in order to make the findings more meaningful.

Themes, consistencies and exceptions in the data collected (Hatch, 2002) were scanned for. Data was examined, classified and organised to address the primary objectives of the study. This was done in the questionnaires, beliefs tool, CoRes and lesson plans. The analysis examined the elements of PCK, namely: curricular saliency, content representations, what makes a topic difficult to teach, students' prior knowledge and conceptual teaching strategies for each big idea on Water Resources and their Management. Data analysis was performed simultaneously with data collection, allowing for shaping the direction of future data collection and analysis based on what is or is not being found (Hatch, 2002; Merriam, 1998; Miles & Huberman, 1994). Doing so also improved the quality of the research and allowed for production of credible and trustworthy findings. In the subsequent chapters, I continue the discussion of my data analysis and analytic tools, and show in greater detail how the theoretical framework for the study was applied. I demonstrate how I used the different components of the proposed framework for PCK in EE in analysing the different sets of data to answer the research questions. Below I provide an outline of the data analysis procedures employed for the different tools used in the study.

Analysis of the Beliefs tool

I used the rubric by Luft and Roehrig (2007) to analyse the questions adapted from the TBI. This is a spectrum from teacher-centred to student-centred beliefs about teaching. I coded the responses of the participants on a range of 1 to 5, the lowest number representing the most teacher-centred beliefs (see table 2.2, p. 30). To analyse the questions that are not adapted from the TBI, I used the 7 roles of teaching as per the South African Norms and Standards for Educators to categorise the data. This describes the *roles*, associated set of *applied competences* (norms) and *qualifications* (standards) for the development of educators, as well as the key strategic objectives for the development of learning programmes, qualifications and standards for educators (Republic of South Africa, 2000). The roles described by the South African Education Policy, Norms and Standards for Educators are in sync with the Botswana Government representation of teachers and they yielded more material for PCK (see table 2.3). Some of the roles, such as Learning mediator, Interpreter and designer of learning programmes and materials, Scholar, researcher and lifelong student and Learning area/subject/discipline/phase specialist and assessor are representative of the subject-specific knowledge, which is of importance in this chapter.

The questions asked on the reasons for choosing teaching as a career and the characteristics of an effective teacher generated responses that were not all specific to the subject and knowledge for teaching, hence the need to use more than one way of analysing the data. The analysis was divided into two parts. The first part of the analysis looked at all responses for question 1 (choice of teaching as a career), 2 (why they love teaching), 4 (important things that make one an effective teacher) and 6 (job that is similar to teaching). The responses for each question were grouped and thereafter categorised, according to the 7 roles of the teacher, using tables and frequencies. This is done to help establish trends and patterns in the data. The results for each question were then described and meaning established from the data. For question 3 on the challenges teachers face in their jobs, I employed a more grounded approach

where I let the teachers' responses generate the categories. I sorted the responses and came up with categories from the data.

The second part of the analysis was done using the categories by Luft and Roehrig (2007). This applies to question 5 (how one maximises learning), 7 (statements about effective teaching), 8 (knowing if students understand) and 9 (how students learn best). The responses were sorted according to the spectrum of categories (1 to 5). This classification of responses was done with the help of the question maps developed by Luft and Roehrig from the responses for the teachers for the different questions from the beliefs tool (see appendix B). Thereafter, the other aspect of the analysis was done using descriptive representational tools, such as tables, frequency graphs and pie charts, using Microsoft Excel for each of the questions. The answers to each question were scanned for patterns, similarities and disparities to help make the data meaningful. I analysed question 4 using both the 7 roles of the teacher and the Luft and Roehrig rubric to see if there was any significant relationship or trend in the different strategies employed for analysing the same question.

To substantiate my data, I requested three fellow PhD candidates to categorise the data using both the 7 roles of the teacher and the categories by Luft and Roehrig. I allowed them to categorise the data independently and then we came to an agreement of 83% on the categories as a group. This helped add rigour to the findings.

Analysis of the Content Representations

I used the CoRes to present a brief analysis of each respondent's representation of PCK on Water Resources and their Management in Botswana. For each respondent, I explored most particularly the different kinds of knowledge from which subject matter transformation emerges. These include: curricular saliency, content representations, what makes a topic difficult to teach, students' prior knowledge, and conceptual teaching strategies for each big idea (Geddis & Wood, 1997; Mavhunga & Rollnick, 2011). I adapted a rubric by Mavhunga & Rollnick (2011) to score teachers' responses in the CoRes which correspond to the five components of PCK. This adapted rubric to score the Topic Specific PCK tool is similar to that

used by Park et al. (2010), where the five components of TSPCK were developed and each question rated on a four point scale, from 1 (“limited”) to 4 (“exemplary”). Similarly in my study I also rated each of the components on a four point scale, from 1 – “limited” to 4 -“exemplary”. I developed a description for each component of PCK in relation to the CoRe. Using the guidelines in the rubric, I determined the score for each individual by adding up all the scores for the different PCK components and made comparisons between the PCK components for all the respondents. Table 6.3 illustrates a section of the standards for consideration under teaching strategies in EE related topics. See appendix M for the guidelines for the other components.

Table 3.3. Illustration of the standards for consideration under teaching strategies in EE related topics in the CoRe

PCK Components	(1) Limited	(2) Basic	(3) Developing	(4) Exemplary
Teaching Strategies (in, about, for)	•Provides no evidence of acknowledgement of student prior knowledge and misconceptions •Lacks aspects of curriculum saliency (e.g. corresponding subordinate concepts in a topic, sequencing for scaffolding learning, awareness of the background concepts needed before teaching the topic) •There are few opportunities for student development; Suggested activities are largely teacher centred •Justification for choice of teaching strategy not provided	•Acknowledges student misconceptions with no corresponding confrontation strategy •Lacks aspects of curriculum saliency •Uses a few T/L strategies with little variation, hence limited involvement of students as students are given tasks that develop recall •No justification for choice of teaching strategy	•Overall, strategy workable • Considers confirmation/confrontation of student prior knowledge and/or misconceptions •Considers at least one aspect related to curriculum saliency: sequencing or what not to discuss yet or emphasis of important concepts •Provides justification for choice of teaching strategy but not necessarily aligned to EE •There is evidence of encouraged student involvement; experiments with a variety of T/L strategies hence students given comprehension or application tasks	•Overall , workable strategy to teach required concept •Considers confirmation/confrontation of student prior knowledge and/or common misconceptions •Considers at least two aspects related to curriculum saliency: sequencing, what not to discuss yet, emphasis of important conceptual aspects, etc. •Provides justification for choice of teaching strategy consistent with EE specific strategies (in, about, for the environment) •Highly student centred lesson; thoughtfully selects and effectively uses a variety of T/L strategies appropriate to the content and students.

I validated the tool by providing three of my colleagues with the developed rubric and two CoRes from the focus group to score the CoRes independently. Prior to that, I had to briefly take them through the CoRe, the rubric and what they were expected to do. After we had all scored the CoRes, we reconciled our scores and came to an agreement level of 78%. I then incorporated some of their suggestions and took note of their concerns to consolidate the rubric.

Data analysis for lesson plans and textbooks

To analyse the lesson plans, I looked at all the sections in the individual lesson plans and compared them between the respondents to draw out patterns, similarities and differences. I used the lesson plan guidelines provided in Rusznyak & Walton (2011) to establish the extent of conceptual coherence between the purpose of the lesson, the key questions, the content, student factors to consider in relation to topic, teaching and learning strategies and the sequence of lesson steps. Thereafter, I discussed the general commonalities, differences, and noted some possible omissions and what these would suggest.

Data analysis for the textbooks

In the textbooks, I started by doing a content analysis on the three extracts of the topic Water Resources and Management. Qualitative content analysis involves not only counting words from texts but also attempting to explore the meanings underlying the texts and to generate theory (Hsieh & Shannon, 2005). I examined the content on Water Resources and their Management that was presented in each of the textbooks (see table 7.3.), then explored the order in which the content was presented, and established whether there were any links in the content presented in the texts to the big ideas for the topics. I explored the PCK components of curricular saliency, content representations, what is difficult to teach, student prior knowledge and conceptual teaching strategies to assess the textbook extracts. I was also particularly interested in the most emphasized activities of the teaching strategies as presented in the evaluated textbooks, to help me establish the extent to which they were associated with the goals

and aims of EE. I also looked into the EE methodology course offered at the university at third year for aspects of PCK that were made accessible to teachers to enable them to construct PCK.

Analysis of the questionnaires

In the questionnaires, I sorted the data, identifying patterns, themes, similarities and differences in the responses by using some components of the theoretical framework (see chapter two, section 2.3) and the literature, to help me interpret the data, with respect to the following sub-areas: beliefs about the environment, goals for teaching EE, teacher competencies needed in the teaching of EE, teachers' awareness of students' prior knowledge, curricular saliency (place of topic in curriculum, why teach it), challenges of teaching the topic, knowledge of students, points of misunderstanding and misconceptions about the topic.

To validate the data, I sorted them into categories and requested three fellow PhD candidates to look at the way I organised the data for each of the subsections. I presented the various themes and asked them to categorise a sample of the data. The extent of agreement between our classifications was 82%. Where there were differences of opinion, we sat together to discuss the categorisations. In this way, I was able to reconcile the recommendations and comments from my colleagues amicably. Furthermore, some of the analysed data was given to a colleague for response and presented at a research weekend, and the feedback from both the presentation and the response paper was used to revise and improve the analysis.

3.6. Ethical considerations

Qualitative research explores the world from the perspective of cultural insiders, and researchers' design methods allow them to get to the action and their informants. Participants reveal what goes on behind the scene in their daily lives; they trust researchers with intimate details of their lives and records are made of these accounts (Cohen et al, 2000). It is therefore important to follow ethical procedures when working with human beings as subjects in the research. Rights of participants must be respected. Ethical considerations include informed consent, confidentiality, anonymity, privacy and fairness (McMillan & Schumacher, 2006). I

applied to the University of the Witwatersrand Human Research Ethics Committee for ethical clearance of research involving human participants and was granted a clearance certificate (see appendix J). Certain strategies were used in the study to ensure that the rights of the participants are protected. These include:

3.6.1. Informed consent

Consent protects and respects the right of self-determination of the participants in the research. Participants were invited to be included in the study and were informed prior to data collection what the procedures entailed. They were given the right to refuse to take part (see appendix K), or withdraw once research had begun (Cohen et al, 2000; Bell, 2005; Hatch, 2002). I held briefing sessions with the participants to ensure that they knew exactly what was involved in the research, were fully aware of the purpose of the research and understood their rights. They completed and signed a consent form (see appendix) to indicate whether they would or would not participate in the study.

3.6.2. Permission to conduct research

Permission was sought from the Ministry of Education, Secondary Departments, to gain access to the teachers and the schools (see consent letters in appendix L). I wrote letters to the respective offices, and contacted the responsible personnel directly. The Ministry, University, schools and respondents were provided with the precise nature and scope of the research: the aims, design, methods and procedures to be used, nature and size of samples, the activities to be observed, subjects to be interviewed, time involved, arrangements to guarantee confidentiality, how the findings would be disseminated, a timetable and whether assistance would be required in the organization and administration of the research. Only those who agreed to participate in the study were included in the study. Ethical clearance from the Wits School of Education ethics committee to conduct the research was requested and granted (see appendix J).

3.6.3. Confidentiality and anonymity

A fundamental right of the participants is confidentiality. Information obtained from the participants was used as agreed during informed consent. Respondents would not be identified or presented in identifiable form (Hatch, 2002; Gray, et al, 2007; Cohen et al, 2000). Their anonymity was preserved at all times by ensuring that no names are used in the written report. Teachers and schools were given pseudonyms so that I was the only one who knew how to identify them. Data was kept safe and confidential at all times. This data will be destroyed once the research has been concluded.

3.6.4. Protection from harm

Participants were protected from any kind of harm, physical or psychological. Although the questions asked during interviews were open-ended, they used language that was familiar to the respondent, were as clear as possible, neutral, respectful of the respondent and presumed that valuable knowledge was being disclosed and that the interviews would generate answers related to the objectives of the research (Hatch, 2002; Bell 2005). The interviews were polite, conducted in a comfortable place, well-planned and punctual. The participants were made aware of their right to withdraw from the study at any time (see Appendix K).

3.7. Summary

This section presented my research design and methods which would enable me to examine teachers' beliefs about good teaching and the teaching of EE, teachers' understanding of Water Resources and their Management in Botswana and how the teachers transform their knowledge on Water Resources and their Management into teachable content. I also identified the participants in the different schools and the teachers at the University of Botswana who would constitute the focus group for the study. I justified the selection for participation in my study, discussed how I handled issues of validity and reliability along with the ethical considerations in my data collection, analysis and dissemination. I also indicated how the developed data collection tools related to the research questions

CHAPTER 4: THE NATURE OF TEACHERS' BELIEFS ABOUT TEACHING

4.0. Introduction

Beliefs form an integral part in supporting the formation of personal theories, which, in turn, inform practice (Magnusson et al, 1999). Teachers individually construct beliefs about teaching. These beliefs reveal how teachers view knowledge and learning, and suggest how they may enact their classroom practice (Luft & Roehrig, 2007). That is, a set of beliefs around a particular situation form attitudes and these become action plans that guide decisions and behaviour. People act upon what they believe. There is a link between teachers' beliefs about teaching and practices, and subsequently, their PCK (Davidowitz & Rollnick, 2011; Pajares, 1992). This chapter addresses the research questions for the study that sought to find out the teachers' orientations and beliefs about good practices of teaching of Environmental Education, and how these influence their approach to a topic on Water Resources and their Management in Botswana. This chapter explores teachers' beliefs about teaching in general and the implications of these beliefs on teaching of Social Studies, a subject that integrates EE.

Studies by different researchers have described beliefs in various ways and they also acknowledge their distinctive nature (Moseley & Utley, 2008; Magnusson et al, 1999; Lumpe, Haney & Czerniak, 2000; Luft & Roehrig, 2007). In this study, I consider teacher beliefs as teachers' ways of thinking about and understanding their practice that enable them to mediate learning in effective ways (Ramsden, 2003; Luft & Roehrig, 2007; Morrow, 2007). I adapted the belief categories from the Teachers Beliefs Interview (TBI) by Luft & Roehrig (2007) which include: traditional, instructive, transitional, responsive and reform-based (see section 2.1.2. table 2.2.) Although these beliefs were about science teaching, they are similar to characterisation of beliefs by other scholars in different fields. Beliefs form attitudes which become action plans that guide decisions and behaviour (Pajares, 1992), for example: teachers' practice, instructional decisions and classroom management and events (Luft & Roehrig, 2007). These beliefs constitute a spectrum, with traditional and instructive categories representing teacher-centred beliefs, while responsive and reform-based responses represent student-

centred beliefs. The transitional category reflects a view of students that focuses on primarily behaviourist and affective attributes, with not always cognitive involvement (see Table 2.2, p. 30). The traditional responses are based on facts, rules and methods that are transferable (Luft and Roehrig, 2007).

Teachers have different beliefs and these are particularly influenced by their goals for teaching. The latter could be for student attitude and behavioural change, skills development, real world connections, student development, transmitting facts or knowledge, learning, humanistic values, improvement for pedagogy, social reform/good citizenship or knowledge acquisition (Magnusson et al, 1999). Thus beliefs could be general or discipline-specific.

4.1. Data sources for this chapter

The beliefs tool used in this study is an adaptation of Luft & Roehrig's (2007) Teachers Beliefs Interview (TBI). The tool consisted of 9 questions, all of which sought to uncover teachers' beliefs about teaching using 5 categories. Although the TBI was originally an interview designed for pre-service science teachers, I used it as a questionnaire with in-service Social Studies teachers. The original TBI is explicitly about exploring beliefs about teaching the subject. I included in my instrument more questions that explore teachers' choice for teaching as a career, what they love about their job and challenges in their job in order to explore teachers' beliefs on teaching in general. I also introduced the idea of metaphors, where teachers liken their job to any other and explain why they believe teaching is similar to that other job (see appendix A). The use of metaphors use reveals the "'joint influence' of 'personal, linguistic, cognitive, affective and social, variables'" (Gibbs & Cameron, 2008, p. 67). Metaphors have cognitive, social and affective dimensions (Rusznyak & Walton, 2014; Gibbs & Cameron 2008), and I used them to allow for deeper exploration of what the teachers believe about teaching.

A beliefs tool was administered to a sample of 26 respondents, 21 of which were Social Studies teachers in Botswana Junior Secondary schools, while five were in-service Social Studies teachers who were enrolled at the University of Botswana, upgrading to degree level (B.Ed. Secondary). The beliefs tool consisted of nine questions (see appendix B). The tool attempted

to uncover the teachers' reasons for their choice of teaching as a career, what they love about their job, what they find challenging, what they consider as the most important things that make someone an effective teacher and how they maximize student learning in their classrooms.

They also had to identify and describe a job that was similar to teaching and explain their analogy. They were given 14 statements about effective teaching and had to decide if they agreed or disagreed with these statements. If they didn't agree with any of the statements, they had to state their reason(s). They then had to rank these statements from most to least important. The teachers also had to say how they knew when their students understood something and how they learnt best. Four questions examined general beliefs on teaching while five specifically targeted the teaching of the subject and four were adapted from the TBI. I used the rubric by Luft and Roehrig (2007) to analyse the questions adapted from the TBI. To analyse the questions that are not adapted from the TBI, I used the 7 roles of teaching as per the South African Norms and Standards for Educators to categorise the data.

4.2. Part A of analysis: Beliefs tool

4.2.1. What made you choose teaching as a career?

There are many reasons why people choose teaching as a career. As stated above, I classified these reasons according to the 7 roles of a teacher. Some of the respondents gave more than one reason for choosing teaching as a career but it is evident from the teachers' responses that their choice for teaching as a career is mostly influenced by the teachers' community, citizenship and pastoral roles.

Out of the 33 responses from the 26 respondents, 18 responses indicated that teachers took up teaching because of their desire to assist, serve, guide and help students to meet their needs and goals, to reach their full potential and develop skills. Other examples included responses such as: "*I had a passion and desire to work with children and assist them, guide them and help them make wise choices in life*" (GB3). GM1 similarly responds that she chose teaching as a

career because of the "*Desire to mould, mentor, counsel, guide and make a difference in students' lives*" and KN1 says "*I like working with kids, moulding them*". Irene says she loves helping students unearth their potential and achieve their dreams. Similarly Felicia loves her job because she can transform students into better persons and change their behaviour.

There are those who chose teaching because of their love and passion for the profession, the love of working with children, the interesting aspect of meeting new children, getting to see young people grow and develop and also the fact that "*teaching is the mother of all careers, all pass through the teacher in order to be well groomed professionals*" (GN1). GB3 states that she chose to be a teacher because "*You learn how to deal with people from different backgrounds, cultures and different socio economic groups and you learn to accept them for their difference thus making me as a teacher a better person*". These responses fit well with the pastoral and citizenship role, that the teacher will demonstrate an ability to develop a supportive and empowering environment for the student within the school, and respond to the educational and other needs of students.

Only two responses indicated that teaching had been chosen for purposes of imparting knowledge (GB2) and to be able to contribute towards imparting knowledge and skills to students (Felicia). This correlates with the role of the teacher as learning mediator. On the other hand, there were responses indicating that external forces were the motivation for selecting teaching as a career. In 13 responses, teaching had been chosen as a last resort either due to insufficient entrance qualifications for their desired careers or because teaching was a viable option for stable and secure employment immediately after finishing school. This is exemplified by responses such as: "*Because my form 5 grades only allowed me to apply for Humanities programmes*" (GM2). KN2 states that: "*I had no choice because for social work I was not called for interview. I was admitted for nursing (diploma) and I changed because at University I was admitted for a degree programme*". GMT2 says that "*I chose teaching as a career because I could not find my desired career and time was passing by*" while TM2 explains that "*I needed money to support my family and because I applied late to my first choice of career*". In addition others chose teaching because they needed a secure job upon completion

of their studies. Such responses are not associated with any of the roles of the teacher as stipulated in the South African Education Policy Norms and Standards for Educators.

The data strongly suggests that most of the teachers were motivated by the teachers' community, citizenship and pastoral roles to study teaching. Very few teachers actually mentioned the love for their subject and working with knowledge. The other roles, such as Interpreter and designer of learning programmes and materials, Scholar, researcher and lifelong student and Learning area/subject specialist are not reflected in the responses. It can have negative implications on effective teaching in the classrooms if teachers have little regard for knowledge which many researchers have explicitly indicated as paramount and a prerequisite for good teaching. This knowledge is inclusive of content knowledge, pedagogical content knowledge, knowledge of the students, educational contexts, ends, purposes and values (Shulman, 2004). This teacher knowledge characterises teaching and it is inappropriate for teachers to be motivated only by other things.

4.2.2. What do you love about the job?

Teaching has been described in various ways by different researchers. This question seeks to explore what teachers love about their job. I decide to group the teachers' responses into the different roles of the teacher to see the role that would elicit most responses. This helped to provide another way of looking at the teachers' reasons for loving their job and the role that fits that reason. Table 4.1 shows the role that most teachers identify with. The expectation was that they provided responses that were related to the characteristics of their job and their roles. It was interesting to discover that some felt that they loved their jobs for more than one reason, which was a mixture of two of the categories.

Table 4.1. Summary of teacher responses on the love of their job

Roles of the teacher	Frequency	Examples of responses
Learning mediator	6	• Imparting knowledge and sharing knowledge with students and equipping them with survival life skills (3) • Satisfaction from student good grades and progressing well (2) • Interacting with kids, learning from them especially when they do class presentations
Interpreter and designer of learning programmes and materials	0	NONE
Leader, administrator and manager	0	NONE
Scholar, researcher and lifelong student	2	• being a teacher means one is always learning new things • I am a continuous student and get to acquire more and more skills in dealing with new challenges and exploring new areas of information. Social Studies is an eye opener"
Learning area/subject specialist	0	NONE
An assessor		NONE
Teachers community, citizenship and pastoral roles	17	• counselling, motivating children, give/suggest solutions to their problems, help them unearth their potential and cultivate sense of responsibility in students (11) • interaction between the teacher, students and other people of unique characters and social background (6)
External to teaching	4	• free accommodation • a vacation to make teachers and students rest • a good salary
Total	**29**	

Respondents articulated how they are able to make an impact on the lives of their students, how they love to interact and socialise with other teachers and their students, how they help young people realise their dreams, changing the behaviour of the students and transforming them into better persons. Such responses relate to the community, citizenship and pastoral roles as they are motivated by concern, devotion, interests and the welfare of students. A typical example is that of GM2 who indicated that she loves "*to socialise with students and teachers and I love to counsel children, give/suggest solutions to their problems, help them and convert them to Christianity*". Other responses about why teachers love their job included: "*Changing their lives and being there for them in all ways, guiding and shaping them*" (Irene) and "*producing great people in the society*" (Boitshepo).

Those that espoused the researcher and lifelong student role indicated that they loved teaching because "*I am a continuous student and get to acquire more and more skills in dealing with new challenges and exploring new areas of information. Social Studies is an eye*

opener" (Kagiso). Felicia and Boitshepo love teaching because it allows one to instil knowledge into and share knowledge with students, representative of the learning mediator role. There are those that love teaching mainly because there is "*free accommodation*" (GN3); a "*vacation to make teachers and students rest*" (KN2) and a good salary (Irene), all of which are external to teaching.

The responses tend to assume mostly the teachers' community, citizenship and pastoral roles. According to the South African Norms and Standards for Educators:

> "*The teacher must be seen as a role model at school and surrounding community. The teacher has to uphold the values of the constitution and must be seen to be honest, reliable and dignified. Teachers must have a concern for the care and welfare of students and young people in their care*" (Robinson & Lomofsky, 2010, p. 49.)

It is clear that these teachers are mostly fulfilling their pastoral role while other roles seem unrepresented. Although caring is an essential ingredient in education, it must extend "… beyond a mere personality trait of the teacher, or images of a teacher as nurturing, supportive, patient kind and nice" (Petersen & Osman, 2010, p. 24). Teaching has to be most importantly central to enabling learning.

4.2.3. What would you say are the most important things that make someone an effective teacher?

Effective teaching is reliant on a rich body of content knowledge. Shulman (2004) identified three categories of content knowledge: subject matter content knowledge, pedagogical content knowledge and curricular knowledge. The quality of learning opportunities a teacher can create is dependent on the teacher's conceptual understanding of what is to be taught, as well as his or her ability to make appropriate pedagogical choices, or PCK. I looked at the responses of the teachers in relation to what the teachers express as important things that make an effective teacher, such as knowledge of content, knowledge of students, general pedagogical knowledge, and knowledge of teaching and learning methods. I continued to use the 7 roles of teachers

which have incorporated some of the most important attributes of a teacher. The data indicates that teachers perceive teaching as more representative of community, citizenship and pastoral roles, thus undermining it as a knowledge-based profession with the central role of mediating learning.

Table 4.2. Summary for most important things that make an effective teacher

1. Teachers community, citizenship and pastoral roles	16
2. Learning mediator	14
3. Interpreter and designer of learning programmes and materials	10
4. Scholar, researcher and lifelong student	9
5. Learning area/subject specialist	7
6. External to teaching	5
7. Leader	3
8. An assessor	1

Teachers provided various descriptions of the things they considered most important for effective teaching. These ranged across all the 7 roles, with most responses (16) favouring teachers' community, citizenship and pastoral roles. The other roles that yielded a significant number of responses included the teacher as a Learning mediator (14) and Interpreter and designer of learning programmes and materials (10). The respondents included aspects such as training, familiarity with subject matter and understanding one's subject area to enhance confidence as important things that made one an effective teacher. These concur with research that has emphasised the importance of subject-matter knowledge as a prerequisite for effective teaching, as well as reform-based teaching.

There were also responses that categorised the teacher as an assessor, e.g. checks students' understanding through class exercises and tests and as learning mediator (use of various teaching methods and student -centred learning to cater for all student s, patience and responsibility towards student s and being able to identify his/her needs). Nevertheless, there were responses more characteristic of community, citizenship and pastoral roles of teaching. The following were included as attributes that made one an effective teacher: patience (GB1, GN3, and MM1);

passion, enthusiasm and commitment (GB2); parenting skills (GN1); patient, empathetic and parental attitude (GN3). An effective teacher should also be a good motivator, love the students that they teach, have a parental attitude and have a genuine affection for the kids. There were also responses that were external to the practice of teaching but more relevant to teacher welfare, such as better salaries, proper accommodation and a conducive working environment.

The data showed that teachers believe that to be an effective teacher one needs good personality traits, like passion, patience, empathy, compassion and enthusiasm which are representative of community, citizenship and pastoral roles of teaching. This somehow equates teaching to caregiving and therefore undermines the nature of teaching as a knowledge-based profession. On the other hand, there are those who acknowledge the importance of knowledge as playing a role in teaching, which is encouraging for PCK. However, this falls short of acknowledging other aspects of PCK, like knowledge of context, curriculum, students and teaching methods. Then there are those who believe that a combination of both pastoral roles and knowledge would make one an effective teacher.

4.2.4. Metaphorical comparisons with teaching

The use of metaphors has been identified as a means of accessing how people understand complex concepts through the way one mental domain is conceptualised in terms of another (Lakoff & Johnson, 1980; Rusznyak & Walton, 2014). The use of metaphors therefore plays a central role in enabling abstract thinking and exposing tacit assumptions (Lakoff, 1993). Hence I used them in my study to explore teachers' beliefs about teaching. In this beliefs tool, teachers were asked to identify a job that they felt was similar to teaching and give reasons why. This was done to have an insight into what teachers believed about teaching and how they perceive teaching in their comparisons. The respondents likened the teacher to personnel such as nurses, social workers, pastor, mentor, parent, counsellor, guardian, shepherd, tour guide, artist, manager and bus driver. Most of the careers in this list are motivated by concern and devotion for the welfare and interests of humans - the community, citizenship and pastoral roles. This indicated

that teachers seem to be overly focused on the child-caring aspect of teaching but underestimate the role of knowledge mediation.

Examples of jobs that reflected the teachers' community, citizenship and pastoral role in the responses include:

- TM1 likens teaching to being a **parent** because "*when a teacher comes to class, you have to think of your students as your own children. You deal with problems ranging from reaching puberty, teaching about relationships, counselling about their challenges and provide daily guidance to the students about life. You want to see the children becoming somebody's and to a teacher, the students remain their child forever*"

- KM1 likens a teacher to a **tour guide** because they *guide the young people who are not aware of what the future holds – to the world of careers and also moulding their behaviour. You guide them to tour the various opportunities in life*"

- GM1 likens a teacher to a **pastor** since they "*motivate, guide, know interest in social, spiritually, moral, intellectual development of a student*"

- GB2 likens a teacher to a **parent/mentor** because they " *guide, motivate, discipline, mould, and as a teacher you are a role model to your students*"

- Irene likens a teacher to a **nurse** because "*they take pride in seeing your patient recover from death and waking up to life*"

- Naledi relates a teacher to a **social worker** because "*the teacher is loco parentis to the students. Our students come from different social backgrounds and the teacher has to be there as a counsellor to those who need counselling. The teacher also has to attend to the social needs of the student so that they can perform well in class*".

The jobs that stood out in terms of their justification were those of bus driver, shepherd and manager. The description provided for these jobs by the teachers showed a much more sophisticated understanding of teaching. There was definitely acknowledgement of some characteristics of PCK such as teaching methods, classroom management and knowledge of the students' assessment although not vividly illustrated in the responses. To a large extent, the following descriptions denote the role of learning mediator:

KM2 likens a teacher to a bus driver because "passengers' lives are entirely on the shoulders of the bus driver. His *reckless driving* can destroy many people's lives. Similarly teachers' conduct and performance determine to a large extent failures and successes of students in later life."

MM2 likens a teacher to a shepherd because "just like a shepherd jealously protecting his/her animals, the teacher should always be protective to his/her students. Should ensure that the environment is conducive and promptly detect and element(s) that may deter learning from taking place"

GMT1 likens a teacher to a manager because **"**A teacher owns a class, manages students (traditional), gives tasks to students, checks work given to students, gives feedback and improves on weaknesses."

To verify my results, I compared my responses and allocated roles to Rusznyak and Walton's (2014) eight metaphorical clusters that depict the nature of teacher and student interactions. The following table 4.3 provides a comparative summary of the responses for all the respondents on the job that is similar to teaching and the reason why they liken teaching to that profession.

Table. 4.3. Summary of the responses on the job that is similar to teaching

7 roles of teachers	Job similar to teaching		**Walton and Rusznyak metaphorical categories**
Teachers community, citizenship and pastoral roles (18)	Parent / Guardian	7	Teachers care (17)
	Mentor / Counsellor	3	
	Social workers	2	
	Pastor	1	
	Tour Guide	1	
	Nurse	3	
	Motivational speaker	1	Teachers perform (1)
Learning mediator (5)	Manager	2	Teachers organise
	Bus driver	1	Teachers direct
	Shepherd	1	Teachers organise
	Artist	1	Teachers create
Learning area/subject specialist (3)	Doctor / Medical Practitioner	3	Teachers repair
No response		2	

The fact that most (18) of the responses were aligned to the community, citizenship and pastoral role indicates to a certain extent that teachers are more concerned with child support than knowledge and skill acquisition. Similarly in their study, Rusznyak and Walton (2014, p. 9) found that the highest number of metaphors "depicted the most salient aspect of 'being a teacher' as nurturing students". They argue that although some of the personality traits mentioned in the 'Teachers care' metaphors certainly describe valuable qualities teachers could bring to their practice, these qualities do not identify someone that can effectively enable learning.

4.2.5. What do you find challenging?

Teaching has been described by several researchers as a complex activity that comes with its challenges. To understand the teachers' challenges to teaching, I classified them according to emerging categories from the data (see table 4.4). Teachers identified the following factors as the challenges they face in their teaching:

Table 4.4. Challenges in teaching

Challenge	***Example responses***
Teacher welfare and development (7)	• Little empowerment of teachers by employer thus minimal opportunities for higher learning (2). • Doing a job that one doesn't have a passion for. • Teacher welfare issues such as poor progression and salaries which leads to demotivated teachers (2) • Poor working conditions e.g. congested working place in office, no air cons (1) • The lack of professionalism in the teaching fraternity and this is further made worse by employer (1)
Class sizes and loads (5)	• High teacher pupil ratio – around 40 students per teacher who is to give them individual attention making students individual attention difficult or restricting teaching techniques (4) • A lot of paper work interfering with teaching. (1)
Student diversity (5)	• Teaching children with learning disabilities – which make it difficult for them to understand what is being taught, especially those who cannot read and write, this puts pressure on the teacher to catering for the students' and produce good results despite the students' different capabilities (4) . • Dealing with children from different backgrounds and having to be sensitive about their needs (1)
Student behaviour and attitudes (4)	• Unruly students and with a negative attitude towards learning and want to be pushed around (2). • Combating students negative perceptions about education, because ultimately educators can only do so much, one's success is up to them and the dedication they choose to pursue it (2)
Resources (4)	• Lack of support systems in the schools particularly for weaker pupils - The resources, time and personnel for social welfare is not adequately provided. (2) • Lack or resources such as textbooks, stationary, tables, chairs, making it difficult to teach (2)
Curriculum(2)	• Curriculum change - syllabus which is relatively new, challenging, too long, congested and most of the objectives are higher in level for the students (2)
Lack of parental support (1)	• lack of parental support (1)

Challenges identified by teachers include issues on: curriculum (congested syllabus that is relatively new and challenging to the teachers), student diversity, undesirable student behaviour and attitudes, large classes and teaching loads, and lack of resources. Most of the above problems are more focused on resources, teacher welfare and development and lack of parental support. These challenges reflect more on the issues of context which is an attribute of PCK and can impact on the way the teachers teach.

4.3. Part B: Analysis of beliefs tool using the Luft and Roehrig rubric

In the sections below, I analyse the questions adapted from the TBI using the belief categories by Luft and Roehrig (2007), which constitute a spectrum of 1 to 5. These are: 1. Traditional; 2. Instructive; 3. Transitional; 4. Responsive and 5. Reform-based (see section 2.1.2, table 2.2., p. 30). Although the categories were used in Luft and Roehrig (2007) to establish the belief pattern of individual teachers, I used these categories to help explore teachers' beliefs about subject-specific teaching. This data on the established beliefs is used later in this study as baseline data for the analysis of data for the smaller focus group sample. While working with the data, it became clear that the respondents provided more than one answer for some of the adapted questions, while some were left unanswered. Furthermore, some of these responses for a question included different categories, so the totals for responses exceeded the number of the respondents. To address this challenge, I concentrated on the frequencies and pattern of responses for each belief category for an overall picture of all the teachers. For all the adapted questions, I looked at the responses and established the belief category which I have indicated with a star (*****) symbol to show frequencies. Ultimately I established the dominant belief category of the teachers using these frequencies. The table 4.5 is a summary of the responses for all the questions adapted from the TBI by Luft and Roehrig (2007).

Table 4.5. Summary of responses for question 5, 8 and 9

Respondent	***Traditional (1)***	***Instructional (2)***	***Transitional (3)***	***Responsive (4)***	***Reform based (5)***
GB1		*		*	
GB2		*	*	*	
GB3			**	**	
GM1			**	*	
GM2		*	*	**	
GM3		*			
GM4	*	**		*	
GMT1		*	*	**	
GMT2		**	*	**	
GN1		*		**	
GN2			**	*	
GN3		*		*	
GN4		*	*		
KM1		*	*	*	
KM2		*		**	
KN1			*	**	
KN2		*		**	
MM1		***		*	
MM2				***	
TM1			*	**	
TM2		*		**	
Boitshepo		*		**	
Felicia			**	*	
Irene		*	**	*	
Kagiso		**	**	*	
Naledi			*	*	
TOTAL	***1***	***23***	***21***	***37***	***0***

It is clear from the summary that most (37) of the responses by the teachers centre on responsive beliefs while there was an almost equal representation for the instructive and transitional beliefs. Overall, the data indicates that the teachers acknowledge to a certain extent the need to involve the students in the learning process. They believe in teacher/student relationships, subjective decisions or affective responses, as well as in collaboration, feedback or knowledge development; that is, designing the classroom environment to enable the students to interact with each other and their knowledge (Luft & Roehrig, 2007).

Below I briefly look at each of the questions individually and provide an insight into the teachers' beliefs about maximising learning, how the teachers know if students understand and how they learn best.

4. 3.1. How do you maximise learning in your classroom?

Several theorists have described different ways in which learning takes place. Examples include observational learning theory (Bandura, 1977), constructivism (Bruner), learning by doing (Dewey), behaviourism (Pavlov, Piaget, Thorndike and Skinner) and many others (Papalia & Olds, 1989; Wals, 2007). Most of these learning theories advocate learning situations in which students do not remain passive recipients of information but should also be involved in the learning process. Preference is given to student-centred over teacher-centred approaches to teaching and learning. Teachers were asked to describe ways in which they maximised learning in their classrooms. In order to classify the response of the teachers, I used the question map by Luft and Roehrig (2007), (see Fig 4.1.below).

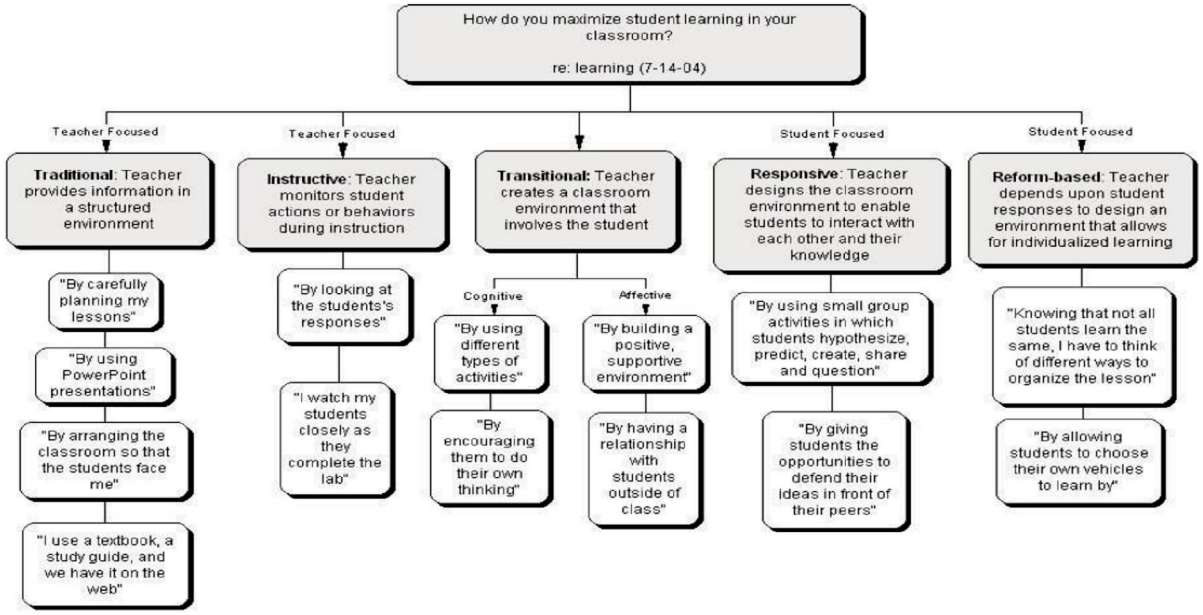


Fig. 4.1. Belief question map on maximising learning (Luft and Roehrig, 2007, p. 57)

I classified the responses for each teacher according to the categories for the TBI. Table 4.6 below summarises the responses of the teachers on how they maximise learning in their classrooms. It is interesting to note that some of the respondents had more than one response and these were not necessarily from the same category. This resulted in a higher total number of responses than the number of respondents.

Table 4.6. Summary of responses on maximising learning in the classroom.

Respondents	**Traditional 1**	**Instructive 2**	**Transitional 3**	**Responsive 4**	**Reform based 5**
GB1				*	
GB2				*	
GB3				*	
GM1			*		
GM2				*	
GM3					
GM4		*			
GMT1				*	
GMT2		*	*	*	
GN1				*	
GN2			*		
GN3					
GN4			*		
KM1					
KM2				*	
KN1				*	
KN2				*	
MM1		*		*	
MM2				*	
TM1				*	
TM2				*	
Boitshepo				*	
Felicia			*		
Irene			*		
Kagiso		*	**		
Naledi			*	*	
Total	**0**	**4**	**9**	**16**	**0**

The majority of the responses pointed to the responsive beliefs which are characteristic of interactive learning and the involvement of students through group work activities, presentations, panel discussions and debates. Some examples of the responsive responses are as follows:

- Involving them in class discussions through group work

- Group discussions, debate and regular exercises
- By engaging them in interactive learning methodologies to maximise their comprehension

There were very few instructive responses. The transitional beliefs were lower than the responsive ones although a significant number of responses indicated that some teachers had transitional beliefs. Examples of transitional responses for maximising learning included humorous lessons, democratic classrooms, very minimal punishment especially corporal, using different student-centred methods. Some teachers maximise learning by giving notes in advance and using assignments. It is apparent from the data that most of the respondents maximise learning in their classrooms by creating a classroom environment that involves the students. They believe in a classroom situation that allows the students to interact with each other and their knowledge.

4.3.2. How do you know if your students understand?

This question has a lot to do with the ways in which teachers ascertain student understanding, that learning has occurred in their classrooms. SMK plays a large part in producing suitable assessment tasks (Rollnick et al, 2008). The teacher needs a rich knowledge of the content taught to be able to develop sound assessment activities. I continued to use the question map by Luft and Roehrig (2007) to classify the responses by the teachers (see appendix B). In this study, the dominant responses reflect instructive and transitional beliefs (see Table 4.7. below). Teachers ascertain students' learning through assessment tasks, like tests and assignments which they give to the students or by measuring their level of participation in the classroom activities.

Table 4.7 below further demonstrates the teachers' beliefs on ways of ascertaining that their students understand. Most of the responses (17) reflected instructive beliefs on ascertaining that students understand, which is more teacher-focused. From their responses, teachers know that their students understand: when students give precise answers; when they score high marks in exercises and tests; when they do well in the exercises they are given; when they can

put in their own words what they learnt, not just regurgitating what they were told and when they pass quizzes and tests given by the teacher.

Table 4.7. Summary responses on ascertaining students understanding (n. 26)

Respondents	Traditional 1	Instructional 2	Transitional 3	Responsive 4	Reform based 5
GB1		*			
GB2			*		
GB3			*		
GM1			*		
GM2		*	*		
GM3		*			
GM4		*			
GMT1		*	*		
GMT2		*			
GN1		*			
GN2			*		
GN3		*			
GN4		*			
KM1		*	*		
KM2		*			
KN1			*		
KN2		*			
MM1		*			
MM2				*	
TM1				*	
TM2		*			
Boitshepo		*			
Felicia			*		
Irene		*	*		
Kagiso		*	*		
Naledi			*		
Total	**0**	**17**	**12**	**2**	**0**

A good number of responses reflected that teachers also had transitional (12) beliefs about finding out if their students understood. They knew that their students understood when they become quite enthusiastic, participated in class discussions and were able to make additional contributions, questioning the content and seeking clarity, as well as critically analysing the implications of what they learnt on themselves, their immediate environment and outer environment.

Only one response corresponded with the reform-based category. The reform-based beliefs are more student-focused and become evident when the students can apply knowledge in a different setting or construct something innovative that is related to the knowledge. An example of such a response is by GMT1, that the teacher would know if the students understood "When they can apply what they learnt in real life situations e.g. whether they can interpret things from the theoretical to the practical e.g. through projects in their environment". Respondents, such as KM1, Irene and Kagiso interestingly had more than one response for this question.

Good teachers use frequent formative assessments to map progress and to build new learning; furthermore, they use assessment strategies that call for evidence of deep understanding, not superficial recall. On the contrary, the responses in this study are more instructive and gauge learning through recall and comprehension which are at the lowest level in Bloom's taxonomy. This limitation could be attributed to insufficient SMK or deficient PCK.

4.3.4. How do your students learn best?

There are several ways in which students learn but it is evident from the teachers' responses that their students learn best when they are involved in the learning process, by encountering and interpreting phenomena (Luft & Roehrig, 2007). This involves students interacting with each other in trying to explain data and create their own understanding of the facts, or responsive teaching. A minute number of the teachers argue for the traditional, instructive and reform-based beliefs as the best way in which their students learn. The majority of responses favoured responsive beliefs which are more student-focused.

Examples of responses that argue for responsive teaching are as follows: GB3 uses student-centred activities, such as: "Involving them in learning i.e. demonstrations, debate, panel discussions etc." GMT1's students learn best through "Interactive learning when they are given work to tackle in groups e.g. group discussions and presentation" while for GN2 they learn best "when student-centred methods are used e.g. role play and group presentation." This is the same

for KM2 who says “Some notable comprehension is achieved when they were engaged in group discussion and presentation”.

For other teachers, a combination of the responsive and reform-based beliefs are reflected in the best way for their students to learn, like, for example, TM1’s students, who learn best when “they are the ones providing the information after undertaking their own research. They also learn by engaging in independent group discussions where everyone can bring in their own views”. Similarly for TM2, whose students learn best through “Group work and presentations and also when they research and report back to class”. The literature agrees that the students learn best when they are given an opportunity to also play a part in the learning process.

How then can teachers come up with sound teaching methods if they have insufficient content knowledge? Morrow (2007) argues that one big problem that teaching is construed as generic activities, that is, coming up with different activities to be done by the students as learning activities, without much consideration of the content.

4.3.5. Teachers’ perceptions about effective teaching

Teachers were given a list of 14 statements about effective teaching and asked to indicate whether they agreed, partially agreed or disagreed with statements. These statements represented a mix of beliefs. I classified the statements according to the different beliefs category using the Luft and Roehrig’s spectrum (see fig 4. 2 below).

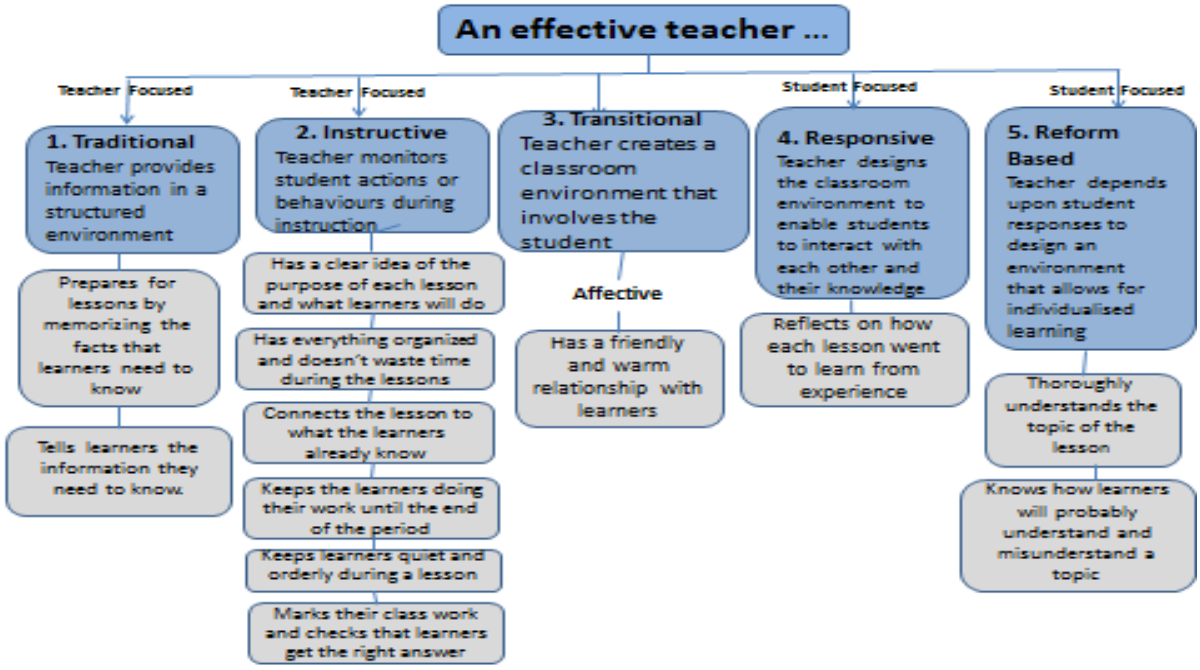


Fig. 4.2. Classification of statements about effective teaching

Once the teachers had answered these questions, I used averages to establish the least and the most important statements about teaching as expressed by the teachers. Thereafter, I examined the statements to establish the probable beliefs pattern regarding effective teachers. The statements that most teachers agreed with were the following:

Table 4.8. Most important statements about effective teaching

Statements	Beliefs Category
4. Thoroughly understands the topic of the lesson	5. Reform based
5. Has everything organized and doesn't waste time during the lessons	**2. Instructive**
7. Marks their class work and checks that student s get the right answers	**2. Instructive**
8. Reflects on how each lesson went to learn from experience	4. Responsive
11. Has a friendly and warm relationship with student s	3. Transitional
13. Has a clear idea of the purpose of each lesson and what student s will do	**2. Instructive**
14. Connects the lesson to what the student s already know	**2. Instructive**

Although the responses are a mixture of different beliefs categories, the **most** important statements about teaching, as indicated by the teachers, were representative of instructive

beliefs. The least important statements included mostly the traditional and instructive category of beliefs. This suggests that teachers, to a certain extent, acknowledge the need for the student to be involved in the learning process since they disagreed with the traditional teaching strategies where the teacher is the sole custodian of the teaching and learning process.

Table 4.9. Least important statements about effective teaching

Statements	Beliefs Category
Keeps student s quiet and orderly during a lesson	**2. Instructive**
Tells students the information they need to know.	**1. Traditional**
Keeps the student s doing their work until the end of the period	**2. Instructive**
Reflects on how each lesson went to learn from experience	5. Reform based
Knows how student s will probably understand and misunderstand a topic	5. Reform based
Marks their class work and checks that student s get the right answer	**2. Instructive**
Prepares for lessons by memorizing the facts that student s need to know	**2. Traditional**

Despite their disagreement with the teacher-centred beliefs approaches to teaching and learning, as per the ranking for the least important statements about effective teaching (see Table *4.9*), the teachers' responses indicate that attributes of PCK and Pedagogical Reasoning and Action (PRA), such as knowledge of the students, assessment and reflection are not highly considered by the teachers. This is shown by their disregard for statements that focus on student-centred beliefs, particularly knowledge of how student s understand and misunderstand a topic, and reflection on how each lesson went, to learn from experience.

4.4. Discussion

Beliefs reveal how teachers view knowledge and learning, consolidate knowledge and information, and suggest how they may carry out their classroom practice (Luft & Roehrig, 2007; Moseley & Utley, 2008). Teachers may have different goals about teaching, depending on their beliefs about what constitutes good practice, even in EE. Furthermore, the activities provided for the students largely depend on the skill the teacher believes is important to develop (Magnusson et al, 1999). This chapter sought to explore teachers' beliefs about teaching in general and about the subject Social Studies. EE is infused and integrated into the

subject so unearthing the teachers' beliefs will illustrate to a greater extent what some of their goals for teaching could be: student attitude and behavioural change, skills development, real world connections, student development, transmitting facts or knowledge, improvement for pedagogy, social reform/good citizenship or knowledge acquisition (Magnusson et al, 1999).

The findings from the general beliefs about teaching indicate that teachers were mostly motivated by community, citizenship and pastoral roles to choose teaching as a career. This also applies to what they love most about their job. They also joined the profession for reasons that related to their wellbeing or welfare. There is little mention of any love for their subject and working with knowledge. Many scholars have maintained that subject matter knowledge is a prerequisite for teaching. The little regard and lack of representation for knowledge, which characterises teaching, in the teachers' responses could have negative implications on effective teaching in the classrooms. Teaching has been argued to extend beyond being nurturing, supportive, patient and kind (Petersen & Osman, 2010, p. 24). It should most importantly be central to enabling learning.

Teachers believe that to be an effective teacher, one needs qualities such as patience, empathy, compassion and enthusiasm. The aforementioned are more characteristic of the community, citizenship and pastoral role of teachers. This thinking and belief about teaching equates teaching to caregiving, and therefore somewhat undermines the nature of teaching as a knowledge-based profession. The job of the teacher is not mainly about caring for others, but to mediate learning (de Beer & Gravett, 2010). There is an indication from the data that some of the teachers indeed misunderstand the nature of teachers' work, which is to *teach* (Morrow, 2007).

Some of the teachers concentrate on the peripheral goals of the teacher and do not look at making knowledge accessible to the students. They focus on the interpersonal qualities of the teacher and the emotional needs of the student and not the students' knowledge (Morrow, 2007). There is an indication from the data that some of the teachers surely misunderstand the

nature of teachers' work. The respondents are motivated to be teachers so as to assist, serve, guide, mould and help students meet their needs and goals.

A significant number of responses also pointed to the importance of knowledge as playing a role in teaching. This acknowledgement is positive for PCK. There was acknowledgement of the importance of some components of PCK, such as knowledge of subject matter and general pedagogical knowledge, thus indicating a sophisticated understanding of teaching as a knowledge-based profession. However, their responses did not adequately represent other aspects of PCK, such as the knowledge of the students, context and pedagogic knowledge. There were some teachers who believed that a combination of both pastoral roles and knowledge would make one an effective teacher.

In the second part of the analysis, teachers gave examples such as group work, presentations, panel discussions, debates and discussions as ways of maximising learning in their classrooms. They explained that their students learn best when they are involved in the learning process through student -centred activities, such as group work, discussions and presentations, thus their responses tended to have beliefs that were responsive. This is an indication that the teachers, to a certain extent, acknowledge the need to involve the students in the learning process. There was also an illustration of the instructive and transitional beliefs by the teachers. They believe in teacher/student relationships, subjective decisions or affective responses, and also in collaboration, feedback or knowledge development. They favour designing the classroom environment to enable the students to interact with each other and their knowledge (Luft & Roehrig, 2007).

It is evident from the data that teachers do have different beliefs with regards to teaching. Entities can "... hold beliefs that are independent of one another and have a varied impact in actions and cognitive processes. This means that individuals can hold beliefs that are in conflict with one another, that have different representations, and that are generalizable and context specific" (Luft & Roehrig, 2007, p. 40). This finding also suggests that teachers believe that they can choose methods irrespective of content i.e. generic methods that can be randomly

selected. This totally undermines the importance of PCK in teaching. This implies that one can just choose effective strategies, even if they do not have content knowledge and PCK.

Although beliefs are important in helping us understand how teachers view knowledge and learning and their decisions about classroom practice, it is important to also consider these beliefs alongside research trends on effective teaching generally and in EE. Social Studies and EE both aim at developing the student's awareness, understanding and skills through student-centred methods (see 1.2.2, p. 4). It is therefore paramount that the teachers have a profound PCK that allows them to achieve this aim. In the study, I began by asking questions that targeted both general and subject related matter and I also asked questions that targeted subject-specific roles. The questions adapted from Luft and Roehrig are more fine-tuned and subject-specific. It is interesting that only a few responses reflected subject-specific responses, but my study is more focused on subject-specific knowledge and roles for teaching. Very few teachers position themselves here.

The goals of EE are aligned to depend on reform-based teaching which is set in in constructivism and is characterised by enabling the construction of learning goals, evaluating the effectiveness of instruction, focusing student inquiries and coordinating dialogue and interaction among students about various ideas. This also includes supporting students to develop responsibility for their own learning by encouraging the skills of scientific inquiry and curiosity (Park et al, 2011). This kind of teaching is reliant on a rich knowledge of the subject matter. Reform-based beliefs focus on mediating student knowledge or interactions, and are highly student-centred (Luft & Roehrig, 2007). Very few, or none, of the responses by the teachers reflected reform-based beliefs about learning. Few responses acknowledged the importance of the knowledge of subject matter and student interaction with various ideas to supporting the development of the skills of scientific inquiry.

4.5. Summary

This chapter unearths teachers' beliefs about teaching in general. It sheds light on how these beliefs could ultimately influence the teaching of environmentally-oriented topics, such as

Water Resources and their Management. Literature has strongly indicated that for a teacher to be able to organise and foster systematic learning, he/she needs a good basis of content knowledge and a developed PCK. This chapter shows that teachers have different beliefs about teaching, that is, teaching as a knowledge-based profession and as a community, citizenship and pastoral responsibility. The chapter also explores what teachers believe to be the contextual variables influencing teaching. Bandura (1977) asserts that teacher efficacy is context and subject-matter specific. Thus, teachers "feel efficient for teaching particular subjects to certain students in specific settings, and they can be expected to feel more or less efficacious under different circumstances" (Moseley & Utley, 2008, p. 16). The issues identified as challenges influence teacher thinking and practice.

The chapter did not cover the teachers' views about the environment, their beliefs as to best practices of approaching topics about the environment or about teaching EE. This will be done in chapter 5, which will explore the teachers' beliefs about EE teaching and content knowledge on Water Resources and their Management in Botswana.

CHAPTER 5: BELIEFS ABOUT THE ENVIRONMENT AND PCK ON EE

5.0. Introduction

Having established that few teachers show the reform-based teaching beliefs as advocated by EE proponents, I address sub research question one which looks at teachers' orientations and beliefs about teaching Environmental Education. This chapter also explores teachers' content knowledge of Water Resources and their Management in Botswana and their pedagogical knowledge of how to teach these topics effectively hence addressing sub research question two and three.

Teachers' beliefs about the environment could affect what and how they teach; hence this chapter explores teachers' beliefs about the environment, knowledge and understanding about water in Botswana and EE teaching. The chapter is organised into three categories: teachers' beliefs about the environment, teachers' knowledge and understanding about Water Resources and their Management in Botswana and teachers' beliefs about EE. I use sources from the literature on different environmental beliefs, water in Botswana and Environmental Education in Botswana to guide my analysis and discussion.

5.1. Data sources for this chapter

A self-completion teacher questionnaire (see Appendix C) was administered to 26 respondents - 21 social studies teachers in the Junior Secondary school and 5 in-service teachers at the University of Botswana. The questionnaire explored the teachers' subject matter knowledge, PCK and beliefs about the environment and teaching of EE topics, and contained open-ended questions. It consisted of four parts (see Appendix C). Part I included background or demographic data; Part II explored the teachers' environmental views; Part III targeted the teachers' subject matter knowledge on Water Resources and their Management in Botswana and Part IV established teachers' PCK on the teaching of EE.

5.2. Teachers' beliefs about the environment

Investigating human views of the environment is a challenging task because there is not, nor has there ever been, any one single way that humans have viewed the environment (Kearney, 1999). That is, environmental views are not necessarily fixed; they can be a mix, which is a combination of both technocentric and ecocentric. In this study, I set up a binary using the ecocentric and technocentric viewpoints as described by Job (1996), to see how participants position themselves along a spectrum of the two extremes. The technocentric perspective views the earth "as machine whose operations can be understood, predicted and managed using the tool of science" (Job, 1996, p. 56). This perspective holds that people are predominant over all other forms of life, and is characteristic of increased levels of consumption and development of technology by man. The human population continues to manipulate the resources found on earth and as these become depleted, they find ways through technology to replace them (Job, 1996).

The ecocentric approach, on the other hand, is based on the notion of sustainable earth with all resources, species and landscape being equal. It is life-centred; recognises the rights of nature and acknowledges the dependence of humans on nature; and maintains a holistic world view that embraces minimum disturbance of natural processes (Job, 1996). This chapter therefore identifies the environmental viewpoints of the teachers to help establish their influence and implications on the teaching of EE topics in chapters six and seven.

Table 5.1. Classification of statements about the environment

Statements about the environment	**Environmental view**
The earth has plenty of natural resources if we just learn how to develop them	Technocentric
The balance of nature is strong enough to cope with the impacts of modern industrial nations	Technocentric
Humans were meant to rule over the rest of nature	Technocentric
The so-called ecological crisis facing humankind has been greatly exaggerated	Technocentric
Plants and animals have as much right as humans to exist	Ecocentric
The earth is like a spaceship with very limited room and resources	Ecocentric
The balance of nature is very delicate and easily upset	Ecocentric
If things continue on their present course, we will soon experience a major ecological catastrophe	Ecocentric
I am very concerned about the environmental issues in my own community	Ecocentric
I am very concerned about global environmental issues	Ecocentric

There were a total of 10 statements about the environment (see table 5.1 above) which were arranged along a continuum and teachers were to indicate the extent to which they agreed or disagreed with the statements. I categorised the statements about the environment as either more technocentric or more ecocentric. Four statements could be classified as more technocentric in nature and 6 as more ecocentric. I then ranked them on a scale of one to five on a Likert scale (see table 5.2 & 5.3). The highest (five) represents a more technocentric view while the lower the number (one), the more ecocentric. Disagreeing with a technocentric statement contributes to an ecocentric score and vice versa. I also used percentages to present the findings*, to* understand the viewpoint/s and to discuss what the outlooks mean for the effective teaching of EE.

Table 5.2: Teachers' views on the technocentric statements about the environment

Technocentric statements about the environment	**Strongly Agree (5)**	**Agree (4)**	**Not sure (3)**	**Disagree (2)**	**Strongly disagree (1)**
The earth has plenty of natural resources if we just learn how to develop them	64.3%	28.6%	3.6%	3.6%	0
The balance of nature is strong enough to cope with the impacts of modern industrial nations	10.7%	7.1%	14.3%	50%	17.9%
Humans were meant to rule over the rest of nature	21.4%	46.4%	3.6%	14.3%	3.6%
The so-called ecological crisis facing humankind has been greatly exaggerated	3.6%	17.9%	10.7%	57.1%	10.7%

The data indicates that out of the four statements that were more technocentric, respondents agreed with two and disagreed with two. About 94% of the respondents agreed that the earth has plenty of natural resources if we just learn how to develop them, while 68 % agreed that humans were meant to rule over the world (68%). Although 68% of the respondents disagreed that the balance of nature was strong enough to cope with the impact of industrial nations, another 68% disagreed that the so-called ecological crisis facing humankind has been greatly exaggerated.

Respondents were asked to indicate their reasons for disagreeing with any of the statements. I categorised their responses according to the technocentric and the ecocentric views. The responses for the 29% that gave their reasons for disagreeing with the technocentric statements suggested more ecocentric-aligned views. An example of the justification provided in their responses was that: “Global warming is an effect of modern industries which means that the balance of nature is not strong enough to cope. The climate is changing as a result of human activities” (GMT1). Kagiso also added that “the misconceptions about the environment are blame shifts for humans’ selfish activities to destroy the environment, resources can never be enough as they will get finished with continued exploitation”. These contentions suggest a perception by the two participants that human activities are responsible for the negative impacts to the environment and the harm to nature’s wellbeing.

The respondents generally agreed with the statements favouring the ecocentric view (see Table 5.3 below). About 92% of the respondents agreed that plants and animals have as much right as humans to exist, while 93% agreed that “the balance of nature is very delicate and easily upset”. 89% of responses stated that "if things continue on their present course, we will soon experience a major ecological catastrophe”. About 97% of the respondents indicated that they were very concerned about the environmental issues in their own communities and all of them agreed that they were concerned about global environmental issues. The teachers mostly concur with ecocentric attitudes, but I noted that the statement “the earth is like a spaceship with very limited room and resources” received the support of only 54% of the respondents.

This difference suggests that more respondents disagreed with this assertion than with any of the others. 25% of the respondents were not sure about the statement, possibly an indication of lack of knowledge on resources around them.

Table 5.3: Teachers' views on the ecocentric statements about the environment

Ecocentric statements about the environment	**Strongly Agree (1)**	**Agree (2)**	**Not sure (3)**	**Disagree (4)**	**Strongly disagree (5)**
Plants and animals have as much right as humans to exist	70.7%	21.4%	3.6%	3.6%	0
The earth is like a spaceship with very limited room and resources	17.9%	35.7%	**25%**	14.3%	7.1%
The balance of nature is very delicate and easily upset	39.3%	53.6%	7.1%	0	0
If things continue on their present course, we will soon experience a major ecological catastrophe	42.9%	46.4%	3.6%	3.6%	3.6%
I am very concerned about the environmental issues in my own community	50%	46.4%	3.6%	0	0
I am very concerned about global environmental issues	53.6%	46.4%	0	0	0

Although it seems that more teachers positioned themselves within the ecocentric view, there were some participants who agreed with one view and disagreed with statements from the other perspective. Some teachers agreed with the ecocentric view and then disagreed with statements for the technocentric view, which is perfectly consistent.The responses to some statements were mixed, but there was predominantly an ecocentric view.

5.3. Teachers' content knowledge and understanding about water in Botswana

In unearthing teachers' knowledge about Water Resources and their Management, teachers were asked questions relating to water issues in the country, i.e. environmental problems in communities, concerns/threats to water resources in Botswana, their thoughts on the recycling of sewerage water and recommendations they could make to help ensure sustainability of water supply in Botswana. First they were provided with a list of environmental problems and were asked to indicate which ones they thought were prevalent in their communities. Among

these problems were water quantity and quality. The idea was to establish the extent to which the teachers identified these two as problems in their communities. The other environmental problems that were included in the environmental problems included waste disposal and air pollution, which directly affect water quality and, consequently, the availability of water.

According to the data, more than half of the respondents identified waste disposal (93%), air pollution (54%), soil degradation (50%) and water quantity (50%) as the main problems in their communities, with the most popular being waste disposal (refer to Table 5.4. below).

Table 5.4: Summary of responses on environmental problems (n=26)

Environmental problem	**Frequency**	**Percentage**
Waste disposal	26	93%
Air pollution	15	54%
Soil degradation	14	50%
Water quantity	14	50%
Endangered animals and plants	13	46%
Habitat destruction	13	46%
Water quality	9	32%
Alien vegetation	7	25%
Energy	6	21%

Waste management appeared to be the most prevalent environmental problem perceived in the respondents' communities with a response rate of 93%. Although teachers identified waste disposal as an environmental problem, they did not seem to realise the link between water disposal and water quality; only 32% perceived water quality as a problem.The other problems that were proposed also included air pollution, water quantity and soil degradation, habitat destruction and endangered animals and plants, which all appear in the list of environmental issues identified by the government (Botswana Government, 2007; Els & Rowntree, 2001). Since the study focuses on the teaching about water resources, it was important for this study to probe further teachers' knowledge and understanding on water issues in Botswana, that is, concerns and threats about water supply and quality in Botswanan communities.

5.3.1. Teachers' perceptions of the state of water supply and quality in Botswana

Respondents were asked to identify the problems, concerns and threats about water supply and quality in their communities. Although there were only 26 respondents, some of the respondents provided more than one response, hence the large number of responses. I classified the latter in terms of quantity and quality, and summarised them in Table 5.5. I noted that there were no consequences given for the other concerns and threats. The respondents could identify the problem, but were unable to articulate the consequences or effects, or why this was a problem. Out of the 26 participants, about 6 were able to articulate the consequences.

Table 5.5: Summary of responses on the concerns/threats to water resources in Botswana (n= 26)

Category	Concerns / Threats to water resources in Botswana	Consequence	Frequency
QUANTITY	Unreliable, low rainfall	Shortage of water	19
	High temperatures (High evaporation)		10
	Poor location of dams (poor topography)		2
	Growth in population density and increased water demand (Over exploitation of water)		3
QUALITY	Pollution (pit latrines & industrial waste)	Unsafe water / Compromised health and hygiene	28
	Salty water		7
Total responses			**69**

The various sections identified in this table are discussed below.

Quantity

The most important concerns and threats to the availability and supply of water and of water resources in Botswana

The respondents identified low and unreliable rainfall (19) and high temperatures (10) as two of the threats to water resources in Botswana. Only one respondent was able to attribute low and unreliable rainfall to Botswana being semi-arid, landlocked and highly affected by climate

change (Naledi). On the other hand, other participants attributed it to short rain periods, which cause the insufficient and low quantities of water supply in the country (e.g. GN2, GN4, and Naledi). About 19 respondents stated that due to the shortage and the unreliable water supply in their communities, some areas went for days and, sometimes, even weeks without water or with very low water pressure from the taps (Boitshepo, Felicia, Kagiso, KM1 and KN2). According to the respondents, the frequent water cuts and interruptions also left the people in the communities with little choice but to drink water from the rivers and other unsafe water resources (GB2).

The respondents say that the high temperatures and arid climate lead to rapid drying up of water resources, as a result of high evaporation rates (GM3, GN1, GN2 and KM2). Furthermore, climate change and global warming are identified as currently contributing to the low and unreliable rainfall and the high temperatures that may result in the drying up of the few surface water sources in the country. As GN3 says: "… as the phenomenon of global warming continues to set in, the few surface water sources we have will dry up". The association of global warming with the drying up of water sources, thus conflating aridity with climatic change, may be a misconception caused by lack of understanding of what global warming is, its causes and effects.

Although the respondents listed a few factors attributed to low and unreliable rainfall and water supply, they did not provide responses that suggested an understanding of how the factors interact with one another or how each factor affects the rainfall in various ways. Most responses did not offer reasons but simply described the problem in greater detail.

Two of the respondents (Felicia and Irene) also indicated that water is over-exploited by some people for domestic and commercial purposes; this shows a lack of awareness about the importance of using water sparingly. Also noted in the responses was the poor location of dams, e.g. Gaborone dam, far from rivers, and the difficulties with damming natural channels and perennial rivers, such as the Okavango (Boitshepo, KN2). The claim by the respondents that the dams are far from the towns may be an indication that they are not aware of topographic

constraints for water supply in the country. More importantly, although there is mention of difficulties in damming natural channels, none of the respondents lists these difficulties. These include the sandy soils and flat topography, the reasons why dams are wide and shallow; few suitable sites for dams; low surface run-off; seasonally flowing rivers; and regional and international protocols on shared water resources, like the Okavango River.

On a different note, there were two responses that alluded to wastage of water in the community, asserting that "for the most part if not all the time my community has access to water and that of a good quality; the problem is that we generally don't appreciate the repercussions of wasting water" (GB1).This assertion is supported by the Botswana Vision 2016 (Botswana Government, 1997) that declares that almost all of Botswana's urban dwellers and 90% of its rural people have access to safe water, a significant fulfillment of the Goal 7, Target 7c of the Millennium Development Goals (MDG's) which proposes that nations should reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation. This declaration by the government contradicts the claims made by the respondents who criticize the water quality in the country.

Management of water quantity in Botswana

Respondents were also asked to say what they thought about recycling of sewerage water as an option of water management in Botswana. Out of the 24 responses, a total of 18 (75%) thought that the recycling of waste water was a viable option for water management in the country (see table 5.6 below). The respondents say that since Botswana is landlocked and has a limited water supply, the recycling of sewage water is a way of ensuring sustainable provision of water. There were suggestions that the water could also be used for areas such as agriculture, other industries in the business sector like hair salons and car washes, and for domestic uses, such as toilet flushing and home gardens (GBQ1, GM4, MM1, Boitshepo, GM1, GM2, KN2, TM1, GB2, and GMT1).

Table 5.6: Teachers' thoughts on recycling of sewerage water as an option of water management in Botswana

Response	Clustered Examples of justification
Support recycling of sewerage water (18)	- it can be used in agriculture, gardens, salons (hair) and car washes, toilet flushing & industrial purposes (GB1, GM4, MM1, Boitshepo, GM1, GM2, KN2, TM1, GB2, GM1) - Sewage water will help in the problem of shortage of water. (GN1, GN2,GN3, KM1, KM2) - to reduce reliance on perennial rivers water supply and the dams which may take several seasons of good rains to fill up (GM3,TM1, Felicia) -
Sceptical about recycling of sewerage water (6)	- in doubt of the machinery & the technical expertise used to carry out such a project, purification process (KN1, TM2, Irene) - it can be an expensive exercise, the money rather be used on creating more dams (Irene) - there is need to educate people first because if not they will shun away the project (Naledi)

Although a significant 75% seem positive about the recycling of waste water and see it as a way that could help in the sustainability of water in the country, 25% are a bit sceptical about the idea. Their concern lies in the technical expertise and the machinery used in the process. They feel that the process "is an all-time high standard because it involves high level of risks that may threaten the health security of the human and other life species" (TM2); they are not convinced that the country is ready for such a development. They argue that the "recycling of sewage water can be an option only if the purification process is guaranteed. People are not comfortable with sewage water because they doubt the purification process" (Irene, Felicia). To a certain extent, the sceptical respondents have doubts that the country's national water supply body, Water Utilities Corporation (WUC) is ready for such an innovation.

The WUC is responsible for the provision, treatment of water and ensuring that the water quality is compatible with international standards, so they have the trained personnel, such as chemical and water engineers, to ensure that Botswana receives a good quality of water. It is not clear if the skepticism by the respondents about WUC competence on the recycling of waste water is based on factual information or inaccurate assumptions.

Teachers showed some knowledge related to Water Resources and their Management in the country by identifying the concerns, problems and threats to water quantity. Although the respondents were able to identify and describe some of these problems and threats, their responses did not reveal that they knew how the identified threats affected rainfall and water quantity. There was not sufficient detail, reasons and implications for the problems identified. The teachers had different views on the recycling of waste water. Some viewed the process of recycling waste water as a viable strategy towards water sustainability while others were not convinced that it would be a workable solution. This shows that individuals have different conceptions about the world, and these conceptions influence the way they interact with the world and their cognitive systems.

Quality

Main concerns and threats to water quality in communities

The respondents were asked to identify the main concerns and threats to water quality in their communities. Out of the 69 responses, 41% of the responses identified ground water pollution as the greatest threat to water quality. Common sources of ground water pollution include: industrial waste into aquifer recharge zone**,** leaking septic tank into recharge area, **s**urface runoff from industries, agriculture and homes into abandoned wells, and leaking underground storage tanks of gas stations. In their responses, the teachers attribute ground water pollution to the use of pit latrines by most people in the rural areas **(**GMT1 GM3, GN3, KM1, MM1, Boitshepo and Kagiso), disposal of chemicals, individual dump refuse in rivers and dams**,** and the dumping of industrial waste in channels used by water during rainy seasons, which threatens to contaminate the water resources in the country **(**GM1, GM2, GN2 and GN3**)**. Thus they qualify sewage leakages into the recharge area, and industrial liquid waste from individuals and industries as the main sources of water pollution in the country.

In addition, concern was expressed about the absence of places to dispose of waste water and the drainage systems which have dirty water flowing in the streets and expose people to health-threatening diseases (TM2). 26 respondents see pit latrines as unsafe sewage disposal;

they also pollute underground water which could be an alternative water source, making it unsafe for human consumption (Boitshepo). Els and Rowntree (2001) state that protecting water sources from pollution is a major challenge in Botswana and point out that studies in Botswana have indicated that some groundwater sources are contaminated "with nitrates due to leakage from septic tanks and pit latrines, constituting a potential health threat. Discharge effluents from mining operations include high concentrations of various metals polluting the water resources".

There were also 7 respondents who indicated that the water supplies in their communities were salty and hence did not taste good. For example, KM1 says that "the water that is supplied in Thamaga is salty and contains a lot of chlorine which make its taste not nice'. High salinity of water is one of the problems in Botswana (Els & Rowntree, 2001). Although the respondents mention the salinity of the water, the only indicator they provide to support their claim is the taste. They do not give any other details as to why there are water salinity problems in the country. Furthermore, there could be a possibility of confusion about the nature of pollution, about what chlorine is and what its functions are in the water purification process.

Some responses asserted that the country should be concerned about the quality of water resources because water is the key to a nation's health. They stated that if water is of poor quality, people end up drinking contaminated water and become sick, thus putting more strain on health resources in the country (Irene, KM2, GN3, TM2 and TM1), and threatening human security and economic prosperity. Their reasons were in terms of economic strain on the health-care system.

Although there are local studies that have indicated that some groundwater sources are contaminated by nitrates and leakages from septic tanks, as well as discharge effluents from mining (Els & Rowntree, 2001; Atlhopheng, 1998; Botswana Government, 2007), the respondents seem to suggest that the drainage systems are non-existent and the sewage systems faulty or leaky. These claims could be perceptions and not necessarily a reality of the

situation among Botswanan communities. It is also interesting to note that earlier, when the teachers were asked about the problems facing their communities, only eight of them saw water quality as a problem, but in this instance, water quality may possibly be compromised by water pollution due to inefficient waste management, hence becoming a big concern. Perhaps the teachers do not quite realise the link between water disposal and water quality.

Management of water to ensure sustainable water supply and quality

Good management of water resources goes a long way towards ensuring prolonged availability and quality, and thus sustainability. Water quality requires that the quantity of water resources should not decline over time as this may reduce its total supply, and similarly quantity relies on the quality of water not to decline over time as this may also reduce the total supply of water (Kgathi, 1999). This implies that water quality and quantity are related, as they influence each other. If the water is of good quality, then it increases the quantity available for use. Poor quality of water reduces availability and supply. Teachers were asked to make recommendations on ways in which the government could ensure sustainable water quality and supply. Their answers are shown in Table 5.7. Some respondents provided more than one recommendation so there are more than 26 responses. I decided to discuss those that had a significant frequency of four and above. These included recycling and reusing sewage water (10), Education on water conservation (10), Construction of more dams (9), Rainwater harvesting (7) and Purification of surface/underground water (4).

Table 5.7: A summary of the main recommendations for sustainable water quality and supply in Botswana by the teachers (N=26)

Recommendation	**Frequency**
Recycling and reusing sewage water	**10**
Education on water conservation	**10**
Construction of more dams	**9**
Rainwater harvesting	**7**
Purification of surface/underground water	**4**

Ten respondents recommended recycling and reusing sewage water, intensified education on water conservation and promotion of water harvesting as ways of ensuring sustainable water supply and quality. They saw a need for water conservation education for the entire nation,

both adults and children (Irene, Naledi, GB1, GN2 and TM1). Naledi states that "… the educating should be for attitudinal change not just awareness". Water conservation education should not only be emphasised when the dams dry up, but even during rainy seasons (GB1). Facilities such as radio, village and community (Kgotla) meetings, television, and different venues, such as churches, bars and stadia can be used to spread the message (TM1). There was also stress on cleaning sewer water and reusing it in construction and irrigation to help reduce demand for water (GM1, GM2, GM4, GN1, GN3, MM2 and TM1).

Seven responses stated that the government should encourage people to harvest rainwater (Boitshepo, GM1 and GM2) which they may use for gardening, as well as drill trenches to carry water from rivers such as Okavango and Chobe to where the majority of the population live. The teachers also recommended conservation of rainwater through the construction of more dams across the country (GM2, GN1, GN2, GN3, KM1, KM2 and KN1), as well as the installation of water harvesting and storage tanks by institutions that provide housing for their employees, such as Botswana Housing Corporation (BHC), a multi-housing provider for the country, and the government of Botswana. Another suggestion by TM2 is that the government should take advantage of the perennial rivers like Chobe, Okavango, Zambezi and Thamalakane and source water, as well as build water treatment plants and water storage facilities to maintain constant supply even during times of drought. None of the recommendations suggested ways in which the teachers themselves can play a role in helping the students be more responsible for water sustainability.

Most of these recommendations provided by the teachers are for improving water supply and availability, or quantity. A few aimed at improving the quality of the water. The suggestions included water restrictions and levies, legislation and penalties for water pollution. Overall, it appeared that respondents were reasonably knowledgeable on issues of water management. However, the majority of the respondents' recommendations are already in place and being implemented. There is a National Water Master Plan (NWMP) which is working on making water accessible to all Botswana by constructing dams, transfer schemes through

manufacturing water pipelines and water treatment plants. With regard to the utilisation of the perennial rivers like Chobe, Okavango, Zambezi and Thamalakane, the teachers seem to be unaware of the international agreements and protocols for shared resources. The teachers presented their ideas as new and unconsidered, suggesting that they lack knowledge about Botswana water management strategy. This could have negative implications on the teaching of the factors affecting water resources in the country, especially if the teachers are not aware of the NWMP, which is the national water policy.

5.4. Teachers' beliefs about Environmental Education

Teachers were asked about their beliefs on the teaching of environmental education and what effective teaching of environmental education entailed. To this end, they were questioned about the teaching of an EE-oriented topic that is in the Botswana Junior Secondary school Social Studies syllabus, Water Resources Management and Conservation. The questions covered the importance of learning the topic, the students' prerequisites and the common misunderstandings and challenges of teaching the topic.

5.4.1. An effective environmental education teacher

Literature has argued the importance of teacher knowledge, especially SMK and PCK, for effective teaching. Research sub question one of the study seeks to discover explore effective environmental education teaching hence the teachers were asked about the qualities of an effective EE teacher. The responses from the teachers were clustered to derive classifications of what effective teaching of EE entails. The respondents identified five different characteristics or attributes as shown in Table 5.8. These characteristics were then related to the components of PCK as described in the theoretical framework (see fig 2.3). Although there were 26 respondents, some of them provided more than one characteristic of an effective teacher hence there were more than 26 responses.

Table 5.8: Botswana teachers beliefs about the characteristics of an effective EE teacher (N = 26)

Characteristic	**Frequency**
Knowledge and understanding of the environment and its issues	18
Commitment to the environment and conservation	17
Using appropriate teaching strategies	6
Teaching in context of EE goals	6
Model sustainable Living for student s	4
BLANK	2
Total responses	49

According to the respondents, an effective teacher has knowledge and understanding of the environment and its issues. In three of the responses, teachers state that one should have undergone training and refresher courses, or in-service training, to keep up with changing environmental issues (e.g. GMT1, GM1/2, GM3, GN2/3, KM1/2, MM2/2/3). About 15 teachers indicated that an effective teacher must stay abreast with environment-related matters, i.e. awareness of environmental issues. The teachers acknowledge the importance of keeping up to date with developments and knowledge on environmental issues as requisite for effective teaching.

Concern for the environment and commitment to environmental conservation are key to effective teaching of EE. This is demonstrated in responses such as those that described effective teaching in EE as all about having real concern and an appreciation of the link between our health as people and the environment (2), a positive attitude on conserving the environment (2), passion, love and care for the environment (6), and commitment to environmental values and principles (2). The respondents also believe in sensitising students to sustainable environmental practices, encouraging them to appreciate the role they can play in conserving the environment, and helping them acquire knowledge, developing skills and changing their attitude so that they can participate in ensuring the welfare of the environment (GB2). This will help students appreciate the current environmental issues and learn problem-solving skills (Walker, 1997), suggesting EE in action for the environment. The respondents

seem to understand the national goals of EE as part of the curriculum and how it has to be taught in relation to the situation in the country.

About six of the responses acknowledged the use of relevant and varied pedagogical approaches for effective teaching (GN2) in EE. These include the use of practical examples outside the classroom, for example, “Making the learning of EE practical e.g. by carrying out some environmental tours” (Felicia and GMT1), problem-solving and values education (MM2). This shows knowledge of teaching strategies associated with EE.

According to the respondents, effective teaching also involves students being taught the goals of EE, i.e. awareness, knowledge, attitudes, skills and participation (AKASP) (e.g. Irene, Naledi, GB1, GMT1, MM2 &TM1), or knowledge of context.

Four of the responses stated that an effective teacher needed to be exemplary to the kids, showing them the importance of studying in a healthy environment and practising green consumerism, thus modelling sustainable living for students.

Although 18 teachers acknowledge the importance of awareness and understanding of environmental issues as important for effective teaching, whether they have this deep subject knowledge is entirely another issue. The responses from the teachers do not seem to denote knowledge of the students or EE-specific pedagogical knowledge. More responses seem to dwell on the cognitive and affective domain, so the emphasis is more on knowledge than enactment, in PCK terms. Very little is said about the beliefs of what the teacher actually does or should do in the classroom to enhance effective learning.

5.4.2. Why students should learn about the management of water resources

Teachers were asked why students should learn about the management and conservation of water resources. The question was meant to uncover the respondents’ main reason for teaching the topic Water Resources and Management. It also explores the teachers’ curricular saliency and, to a certain extent, their subject matter knowledge. In their responses, the

teachers identified several reasons for teaching about water resources and their management (see table 5.9 below); they all seem to point to positive attitudes and action towards water sustainability. So I have grouped these responses into categories of proactive behaviours why students should learn about the management and conservation of water resources.

Table 5.9: The main reasons for teaching about Water Resources and their Management

Main reason: Positive attitude and action towards water sustainability	
Examples of clustered responses	**Frequency**
teach student s on sustainable use of water	22
sensitise the student s on the importance and value of water	2
enhance understanding on issues of water scarcity (2	2
Blank	2
Total responses	**28**

Teachers stated that it is important for the students to learn about management and conservation of water resources so that they could actively participate in its practice, and develop good habits that will preserve water for future generations (e.g. Boitshepo, Felicia, GN1, KN1 KM1, KM2 and GB2) - sustainable use. Learning about water resources and their management will "create awareness and promote understanding, which will hopefully promote positive attitude towards the environment" (Naledi). Another reason for students to learn about this topic is so that they can be fully aware of "the importance of water in everything that lives on earth including the environment" (Kagiso). That is when they can "fully appreciate and value water as important and scarce resource and to promote positive attitudinal change towards its use" (Boitshepo). Two teachers also pointed out that students needed to learn about management of water resources so that they could understand that water is a scarce resource in Botswana. This scarcity is attributed to climate change which, according to GM2, may lead to some water resources drying up faster than expected.

It became evident that the most cited reason for teaching about management and conservation of water resources was to promote the conservation and sustainable use of water in the country, which is the EE goal of participation. This echoes sustainability as an ultimate goal for all nations as per the Millennium Development goals and UNESCO goals for the environment.

The teachers seem to understand the need to educate for the sustainability of water; hence they advocate management through conservation and wise use. It is important to note that teachers' understanding is not necessarily action. Most of the responses on why it is important to teach the topic on Water Resources and their Management concentrated on the aspect of water management, and little was said on issues of water quantity and water quality, and how these affect each other. Their reasons for teaching the topic do not probe the topic enough, and this may be an indication of lacking SMK.

5.4.3. What students need to know before they can understand about the management and conservation of water resources

The teachers were asked to identify what the students needed to know before they could understand the management and conservation of water resources, that is, what needs to come before and after this topic. This was done so that students' own knowledge should be taken into consideration as a starting point in understanding EE issues (Cakir, 2008). Even though there were 26 respondents, some teachers provided more than one response, hence the total of 43 responses. These were clustered and categorised, and only those categories that had a frequency of more than five responses, were considered as significant.

Table 5.10: What students need to know before they can understand the management and conservation of water resources (N = 26)

What student s need to know before they can understand	**Frequency**
Importance of water	**17**
The sources of water	**8**
water scarcity and its effects	**7**
Importance of water conservation	**6**
Total responses	43

The most frequent response (17) was that the students need to know about the importance of water to humans and animal species on earth, and to development (KM1, GB1 and KM2). This is because "once students understand the importance, it becomes much easier for them to be able to easily understand the management and preservation methods of water resources"

(GB2). It is interesting to note that earlier when the respondents were asked about why it was important to know about water resources and their management, very few (2) responses acknowledged that students need to understand the importance of water, but here the teachers state that students need to understand the importance of water before they can understand about water resources and management. This could suggest that the respondents assume that the students already know the importance of water, so they see it as prerequisite knowledge.

A further eight responses indicated that students needed to know about the different sources of water: their capacity, locations and water purification processes (Irene, GM2, GM3, GB2, Felicia, Naledi and Kagiso), and seven responses mentioned water scarcity and its effects (GMT1, GN3, Felicia, TM2, Naledi and Kagiso). Furthermore, respondents believe that students should understand why conservation is vital, and acquire knowledge and skills to conserve the water resources, thus how to use water wisely (GB2, GM4).

The teachers' understanding of what students should know before they learn about a topic is because this knowledge sets a logical foundation for the learning of the topic. Since students may come to a learning task with different conceptions about the topic, the teachers have to make sure that the learning experiences for the students are meaningfully designed to cater for the various ideas that the students may bring to class. The teachers' ability to change or reconstruct students' conceptions enhances student understanding and improves their behaviour (Ballantyne & Packer, 1996). Out of the prerequisite knowledge that students should possess before learning the topic, the responses by the teachers identified most of the things that the students would know before they could learn the topic at secondary level. These are covered at both lower and upper primary secondary Social Studies syllabi. There are omissions noted of some of the ideas that the students may know as general knowledge and from upper primary school, such as community-based natural resource management systems and trans-boundary natural resource management systems.

5.4.4. The challenges of teaching about the management of water resources

Successful learning in environmental education (EE) is closely related to the preferred methods used by the teacher and the students. Literature on the teaching of EE argues for a more student-centred approach to learning, i.e. the kind of learning that is more focused on the student. This is contrary to other views that learning should be knowledge-focused. These debates have implications for the role of the teacher and the teaching approaches in terms of teaching and learning, instructional materials, and the way teaching is organised. While other scholars hold that the teacher has to become a coach or a guide rather than an expert, others argue that the teachers must have some knowledge-based authority over the students (see chapter 2, section 2.2.2). To understand their practice more, the teachers were asked to identify the challenges of teaching about the management and conservation of water resources. I have grouped the responses and developed categories from the data (see table 5.11). The challenges identified by the teachers included negative attitudes about wise water use from both students and their community (home and society); lack of resources; lack of parental assistance for students' learning; students' beliefs and misconceptions; and inadequate SMK and PCK of teachers.

Table 5.11: Challenges of teaching about the management of water resources

Challenge	**Frequency**
Student beliefs, misconceptions and negative attitudes by students	14
Shortage of teaching materials	13
Teachers' inadequate SMK/PCK	2
Blank	5
No challenges	1
Total responses	**36**

The responses indicated that the biggest challenge that the teachers faced had to do with the negative attitude of the students towards water management. The respondents attribute the challenge to lack of education on water issues and conservation at home (GB1, TM2) and the lack of responsiveness by the water department. According to the respondents, the water

department that is supposed to be more responsible and responsive to water leaks and pipe bursts, as well as promoting water sustainability does not perform its duties. Hence, students only see water issues as somehow imagined situations (GN3, KN1, MM1 and Irene). The respondents perceive this as making it difficult for the teacher to reconcile home practice and general mismanagement of water resources when it does not seem real to the students.

Another challenge identified by the respondents was the shortage and lack of resources, such as learning reference materials like textbooks for reference, teaching aids (visual aids), ITC facilities and lack of funds for field work/trips. The respondents attribute students' failure to understand water resources to lack of exposure to examples, like rivers and dams.

It is important to note that, according to one of the responses, not all teachers had studied Environmental Science at tertiary level (GB1). Most depended only on information in books, and this was not enough to enhance effective teaching. This poses a challenge to the teachers' subject matter knowledge on environmental issues. A lack of SMK could possibly compromise effective teaching. Another challenge identified was the reliance on traditional knowledge and methodologies used by the teachers which does not promote diversity in dealing with environmental issues (Naledi). Most of the responses addressed the contextual challenges related to the teaching of water resources management, while only very few (2) highlighted the conceptual challenges to teaching. This implies a deficient level of PCK, which is detrimental to effective teaching.

5.4.5. Common misunderstandings children might have about water resources and their management

Knowledge of students entails appreciation of students' prior knowledge, student conceptions or preconceptions, how they learn, their linguistic abilities, interests and aspirations, their learning styles and preferences. Specific understanding of the students' characteristics enables the teacher to focus and adjust instruction according to the needs of the students (Shulman, 1987). The respondents were asked to identify possible misunderstandings their students may have about the topic Water Resources and Management. They stated that the students think

that water is infinite and renewable. That is, “It will always rain; therefore there is not much need for conserving it (water). It is a renewable resource. As humans we have more control and authority over water, therefore we can use it the way we please” (GB1). This kind of misunderstanding might be influenced by the fact that the water cycle suggests this and that most students find water in the pipes and easily accessible. They have no idea of the costs involved and difficulty posed by our climate conditions. “Students tend to think there’s plenty of water” (Kagiso). The misunderstandings are summarised in table 5. 12.

Table 5.12: Students’ misunderstandings on water resources and their management

Misunderstanding	**Frequency**
Water is infinite and renewable	16
Conserving water is not using it at all	1
The authorities like water utilities and Water affairs are the ones with a responsibility for the water	2
Blank	6
No experiences of water outages	2
Unclassifiable	2
Total responses	**29**

The respondents say that students think that there is plenty of water in dams, rivers and boreholes and that it is not scarce, especially in the wetlands, where there is plenty of surface water (Boitshepo and GM2). Furthermore, students feel that they have the right to use water as they please and assume that it is the duty of parents and probably the people in their offices at the water department to manage water (GB2 and MM1). It is evident from the table that the teachers perceive the greatest misunderstanding among students as that of water being infinite; students do not understand that water is a scarce resource that may be depleted, if not managed properly. The teachers also believe that the students also do not always understand their role in ensuring sustainable water use, which could lead to failure to connect their awareness about the environment to actual action or participation for the environment.

5.5. Discussion

The mastery of subject matter is identified as one of the necessary aspects of teacher capacity (Cochran-Smith et al., 2008). The teachers' ability to think and effectively teach relies on a rich body of knowledge about subject matter and a developed PCK (Darling-Hammond & Baratz-Snowden, 2005; Shulman, 1986; Bransford et al, 2000). EE teaching strategies promote learning which is student-oriented and inquiry-based, hence the need for teachers to have in-depth SMK (Tal & Argaman, 2005). In this study, only 35% of the respondents received some pre-service courses on environmental studies and on EE methods (see chapter 3). Furthermore, about 21 of these teachers have been teaching for a minimum of 8 years, which shows that they have been in the service for a long time without the necessary knowledge they need for effective teaching of EE. The chapter explores teachers' beliefs about the environment and about the teaching of EE, and discusses how these views may possibly impact on the teaching of EE. It also explores teachers' perceptions on water resources management and their management in Botswana.

The teachers' responses on environmental views were mostly positioned towards the ecocentric and their justification for disagreeing with some technocentric statements suggested that they understood the need for environmental wellbeing. This presents a possibility for them to help students also realise the need for ecological harmony. Although it is important to sensitise students to the value of the environment and its wellness, Gilbert & Hoepper (1996) caution that students should be allowed to inquire so as to come up with possible solutions to problems and forming their own views on issues (Stradling et.al, 1984). Although it seems as though more teachers positioned themselves within the ecocentric view, there were some who were in agreement with one view and disagreed with statements from other; hence there was an indication that the responses by the participants were mixed.

The responses provided on the questions that sought to unearth their knowledge about Water Resources and their Management in the country, such as knowledge on water issues, threats and concerns, and conservation, indicated that to a certain extent the respondents were informed on water issues, especially in their communities. Although the respondents were able

to identify and describe some of these problems and threats, their responses were not clear as to how the identified threats affected rainfall and water quantity. The responses did not provide adequate detail, reasons, and implications for the problems identified. The teachers had divided views on the recycling of waste water, thus backing the claim that individuals have different conceptions about the world, and these conceptions influence the way they interact with the world and their cognitive systems.

The respondents identified low rainfall and high temperatures as the greatest threats to water supply. They attributed this threat of shortage of water supply and high temperatures to climate change and global warming. Their suggestion that global warming has led to the drying up of water sources may be a misconception driven by lack of understanding of global warming; what it is, its causes and effects. They also identified water pollution as a major threat to water quality, and gave many reasons as to why they perceived water pollution as a major threat. Their assertions seem to suggest that the country has poor or non-existent drainage systems and leaking sewage systems. This is contrary to the declaration by the government that almost all of Botswana's urban dwellers and 90% of its rural people have access to safe water. Furthermore, some stated that the quality of the water was bad as it was salty, had too much chlorine and tasted awful. The association of chlorine with salinity, and the unpleasant taste of water and chlorine presents a likelihood of a misconception due to misinformation or ignorance.

Although the respondents listed a few factors attributed to low and unreliable rainfall and water supply, they did not provide responses that suggested an understanding of how the factors interact with one another or how each factor affects the rainfall in various ways. Most responses did not offer reasons but were simply describing the problem in greater detail. In addition, the claim by the respondents that the dams are far from the towns may be an indication that they are not aware of topographic constraints for water supply in the country. None of the respondents mentions the difficulties in damming natural channels, or sandy soils and flat topography as factors why dams are wide and shallow. The respondents also did not

state reasons why few sites are suitable for dams, why surface run-off is so low, how to deal with seasonally flowing rivers, and regional and international protocols on shared water resources, like Okavango River.

Challenges identified by the respondents included the shortage and lack of resources such as learning reference materials, like textbooks for reference, teaching aids (visual aids), ITC facilities, lack of funds for field work/trips and a lack of subject matter knowledge on EE. The fact that some of the respondents indicated that they had not studied Environmental Science at tertiary level poses a challenge to the teachers' subject matter knowledge on environmental issues. A lack of SMK could possibly compromise effective teaching. It also seemed that the responses provided by the teachers were somewhat limited to what is in textbooks and contained some possible misconceptions. There was reference made to a lack of training on environmental issues, resulting in the teachers depending too much on textbooks for information. This over-reliance on textbooks could also suggest a lack of initiative and innovation on the part of the teachers, to go an extra mile in researching the topics they teach. Textbooks are definitely not the only sources of information teachers have access to. There are other sources, such as the internet, education centres and books at the different libraries across the country.

The recommendations that the respondents provided to government, are mostly in the National Water Master Plan; some of them are already in progress. On the recycling of waste water, most agreed that it was a viable option, except those that were skeptical that the country is not well equipped technically and in expertise. This skepticism may be influenced by lack of information on water processing, availability of human resources in the water engineering field and misconceptions that the community has about recycling of waste water. The teachers' SMK is therefore not convincingly substantial. Other recommendations, such as the construction of more dams across the country along perennial rivers like Chobe, Okavango, Zambezi and Thamalakane suggest ignorance of trans-boundary laws and protocols on shared

water resources and source water. Shared water resources cannot be exploited without rigorous consultation and agreements.

The data indicated that teachers understand the importance of having an understanding of the environmental issues, passion, commitment and promotion of the EE goals, and especially participation in their instruction for effective EE. Teachers acknowledge the importance of keeping up to date with developments and knowledge on environmental issues as requisite for effective teaching. Teachers profess concern for the environment, as well as commitment to environmental conservation as key in effective teaching of EE, and they understand the national goals of EE as part of the curriculum and how it has to be taught in relation to the situation in the country.

Most reasons advanced by the teachers for teaching about management of water resources concerned the promotion of conservation and sustainable use of water in the country - the EE goal of participation. This echoes sustainability as an ultimate goal for all nations, as per the Millennium Development goals and UNESCO goals for the environment. Teachers perceived the greatest misunderstanding among students as that of water being infinite, and students' failure to understand that water is a scarce resource that may be depleted if not managed properly. The teachers also believe that the students do not always understand their role in ensuring sustainable water use, which could lead to failure to connect their awareness about the environment to actual action or participation for the environment.

The National Water Master Plan in Botswana has pointed out the need to give urgent attention to the use and conservation of water in Botswana, as well as harness scarce water resources to ensure an adequate supply of safe drinking water for all citizens. Therefore, the country faces a challenge to establish a sustainable level of withdrawal from the country's water resources for domestic, industrial and personal needs. One of the ways to address this challenge is by ensuring that the education that is provided to the students not only promotes awareness but also action for the environment, thus empowering students to make informed decisions for the

wellbeing of the environment. This can be achieved by employing student-centred education techniques that are based on involving the students in the learning process and the use of different teaching techniques.

5.6. Summary

The chapter attempted to uncover teachers' beliefs about the environment, what they understand about water issues in Botswana and about the teaching of EE. The purpose was also to unearth the teachers' beliefs about good teaching practices of Environmental Education. The findings showed that teachers cared for the wellbeing of the environment and also believed that being up to date about the environment issues, coupled with personal commitment, enabled successful teaching of EE. However, that may not be enough. The teachers also demonstrated some knowledge of the water issues in the country and why it is important for the students to learn about water management and conservation. Although the teachers have some knowledge of environmental issues, the data showed that they lacked awareness on issues concerning water agreements, protocols and processing in the country. This inadequacy is attributed to the absence of training on EE, both issues and methods. Effective teaching begins by knowing the content and being able to communicate it in ways that make it understandable to others, so the implication would be that the teachers may not effectively teach EE due to lack of SMK. Failure to effectively teach any topic, let alone EE, would mean that their PCK is deficient.

The data showed that teachers believed in EE teaching that promoted participation in the environment and not only awareness. This demonstrated an understanding of the goals for EE, both in Botswana and internationally. The next chapter will profile five of the teachers who are at the University of Botswana, who constituted the focus group for the study, and establishes how these individual teachers represent their PCK. This is done by carefully examining their responses to the prompts by the CoRe template adapted from Loughran et al (2004). The teachers' responses to the CoRe's prompts will be interpreted so that a picture representing each individual's thinking on the aspects of PCK is created. Thereafter, observations will be

made for each teacher at the end of the individual examination of the CoRe to see how the findings relate to the research questions.

CHAPTER 6: ANALYSIS OF TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE

6.1. Introduction

Chapter 6 attempts to address research sub-questions three and four, which seek to uncover how Social Studies teachers portray topic-specific PCK on the topic Water Resources and their Management. The chapter also explores the potential of other sources to allow teachers to construct PCK. In this chapter, I focus on the case study group for deeper investigation. I provide a portrait of each of the five in-service teachers that constituted the case study group: Boitshepo, Felicia, Irene, Kagiso and Naledi. I briefly introduce each teacher, and examine their PCK in EE (specific to the topic of Water Resources and their Management) using their CoRes and lesson plans. I also consider the potential of sources such as textbooks and the EE methodology course the respondents in the focus group were studying, to allow teachers to construct PCK.

What is interesting about this case study group is the small variation in teaching experience and subject background. These teachers all hold a Diploma in Secondary Education (DSE), with a Social Studies specialisation and they teach Social Studies. Their biographic details are summarised in table 6.1.

Table 6.1. Summary of biographic details of teachers constituting the focus group

Participant	Gender	Subject specialisation	From (yr.)	To (yr.)	Number of yrs. teaching experience	Studied EE teaching methods	Studied environmental studies
Boitshepo	M	Social Studies	1995	1997	13 years	NONE	NONE
Felicia	F	Social Studies	1991	1993	20 years	NONE	NONE
Irene	F	Social Studies / English	1995	1997	14 years	NONE	NONE
Kagiso	M	Social Studies	1995	1997	14 years	NONE	NONE
Naledi	F	Social Studies / Setswana	1994	1996	15 years	YES	YES

6.2. Teachers' PCK as portrayed in CoRes

Prior to the development of the CoRes and lesson plans, the teachers were asked to draw mind maps to help them conceptualise the topic Water Resources and Management. Figs. 6.1 and 6.2 illustrate how two of the respondents in the sample group conceptualised the topic. The similarity between these mind maps is that they were informed by the three main syllabus objectives on the topic: water sources, factors affecting water and conservation strategies in Botswana, and the guiding sub-topics as illustrated in the Social Studies textbooks used by the teachers and their students. Note that the three branches by Naledi (see Fig. 6.1) also emulate the syllabus and textbooks. Similarly Felicia's mind map is also centred on water sources and conservation, and overlooks the factors affecting water sources.

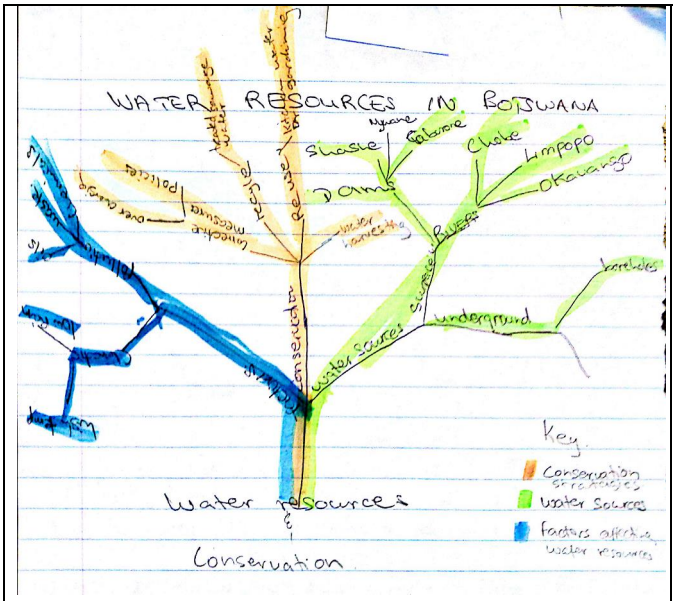


Fig. 6.1. Naledi's mind map of topic water resources and management in Botswana

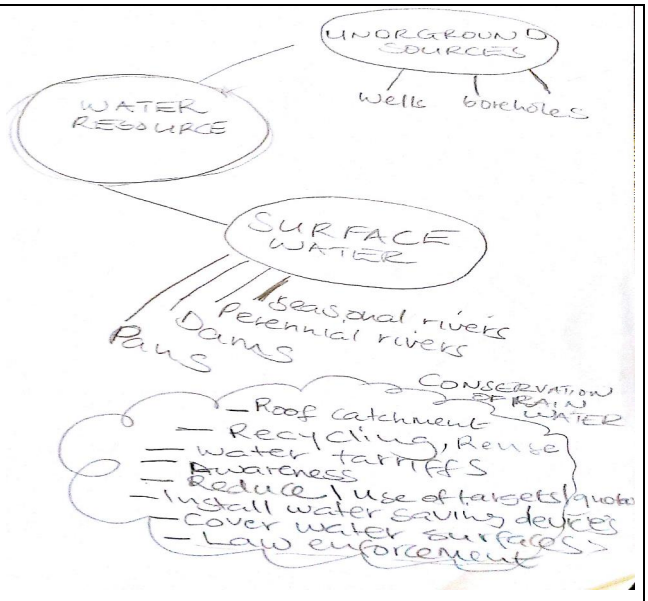


Fig. 6.2. Felicia's mind map of topic water resources and management in Botswana

Thereafter I guided their mind mapping exercise by introducing to them three sub-concepts that would help them explore and probe the topic Water Resources and Management: water quantity, quality and management. There was a great improvement in the depth of

conceptualising the topic, which helped the respondents to deviate from the predetermined sub-concept they had been exposed to in the syllabus and the textbooks (see fig. 6.3).

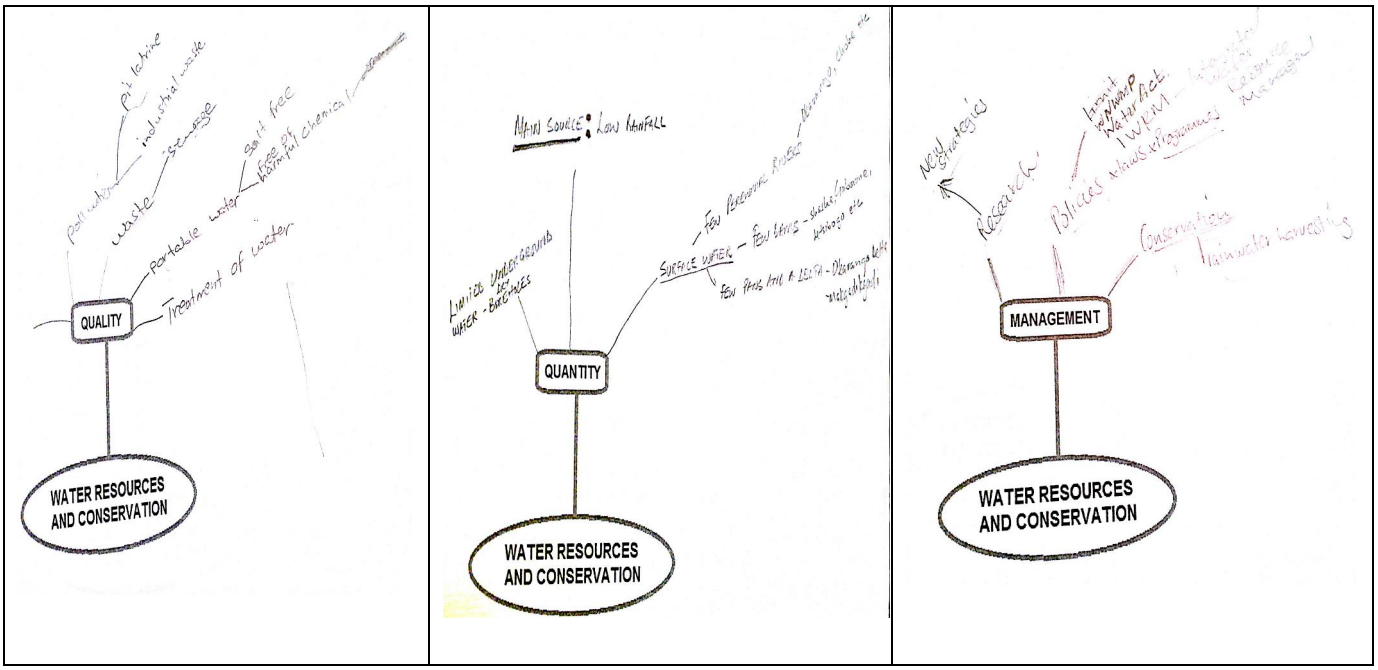
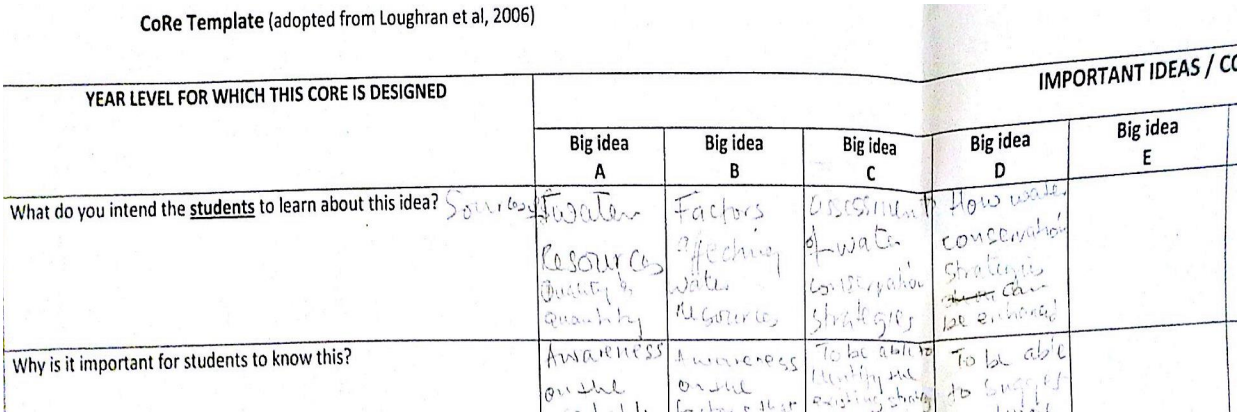


Fig. 6.3. Mind maps on water resources and management by the focus group

Initially during the pilot study, teachers had been asked to come up with what they considered were the Big Ideas of water resources and management. It became evident from all their CoRes that the Big Ideas they had used were the sub-headings for the topic Water Resources and Management in Botswana as per the main prescribed Social Studies textbooks for the Junior Secondary Social Studies syllabus. Their initial attempts to represent PCK then were closely linked to what was provided in the textbooks they used in their teaching. This was common across all the respondents who constituted the focus group. Fig 6.4 illustrates the initial Big Ideas by Kagiso.



CoRe Template (adopted from Loughran et al, 2006)

YEAR LEVEL FOR WHICH THIS CORE IS DESIGNED				IMPORTANT IDEAS / CC	
	Big idea A	Big idea B	Big idea C	Big idea D	Big idea E
What do you intend the students to learn about this idea?	Sources Water Resources Quality & quantity	Factors affecting water Resources	Assessment of water conservation strategies	How water conservation strategies can be enhanced	
Why is it important for students to know this?	Awareness on the	Awareness on the	To be able to identify and	To be able to suggest	

Fig 6.4. Initial Big Ideas by Kagiso

Nevertheless, the process of conceptualising Big Ideas is notably not an easy one (Wiggins & McTighe, 2006), so I provided the respondents with the following workable Big Ideas that could help probe their understanding of the topic and how to teach it:

- Big Idea A - Many human activities depend on access to water
- Big Idea B - Although water is a renewable resource, the amount of usable water is limited by how much can be stored
- Big Idea C - Water can be transported from one region to another
- Big Idea D - Water pollution can decrease its usability

The Big Ideas were provided in the CoRe template for the respondents in the form of a task, where the teachers were asked to complete the CoRe grid on their own. The Big Ideas specified to the respondents were obtained through team conceptualisation of the topic Water Sources and their Management between me and my supervisor, who has expertise in environmental issues. These Big Ideas derive from the main sub-concepts of water: quality, quantity and management.

The teachers generated data through the questionnaire administered, their initial responses to the CoRe, the lesson plans, and the responses from the follow-up interviews that sought clarification on some of the responses from the questionnaire and the CoRe. I then used their various responses to compile a CoRe for each teacher. Although lesson plans are expressions of enactment, in this study they were part of a course work task, hence the PCK that I am

portraying in this chapter is intended knowledge rather than enactment knowledge. Where there were concepts misplaced in the CoRes, I reallocated ideas to appropriate categories so as to create the best possible CoRe for each teacher, which would help establish and access their PCK on the teaching of water resources and management. I also developed an "ideal" composite CoRe for all the Big Ideas which I later use to help develop guidelines to score the CoRes (see appendix M).

6.2.1. A summary of the observations made on each respondent's PCK using the guidelines

On scoring the CoRes using the developed guidelines (Appendix M), it was evident that some of the respondents had a better understanding of the Big Ideas, so they were able to interrogate the prompt from the CoRes in more depth than others. This was demonstrated in their ability to organise their knowledge with fewer conceptual muddles. The CoRes for the different respondents display little PCK as shown in the curricular saliency, content representations or teaching strategies. Table 6.3 summarises the observations and results scored on each respondent's PCK as per the guidelines. The only aspect of PCK that seemed to be developed for most respondents was the awareness of student prior knowledge. Irene and Naledi had a higher overall total when compared to the other respondents, which could suggest that their PCK is more profound than that of the rest of the case study group.

Table 6.2. A summary of the ratings made on each respondent's PCK using the guidelines

PCK components	**Respondents**				
	Boitshepo	Felicia	Irene	Kagiso	Naledi
Curricular saliency	1	1	3	2	2
Content representation	1	1	1	1	2
What is difficult and what is easy	1	2	2	2	2
Student Prior Knowledge including misconceptions	2	2	3	2	3
Teaching strategies	1	1	3	2	3
TOTAL AVERAGE	6/20	7/20	12/20	9/20	11/20

The PCK component that seemed easier for the respondents to display was the students' prior knowledge, including misconceptions. Content representations were the most difficult to display. In the sections, I provide a brief summary of each of the participants and highlight the observations made on each respondent's PCK. Thereafter, I analyse the PCK of the respondents collectively, highlighting similarities and noting differences

6.2.2. A portrait of Boitshepo

Boitshepo has taught for a period of thirteen years in different Junior Secondary schools. He indicated that, while training for the teacher qualification and in his period of service, he had not completed a course on Ecology and Environmental studies or EE teaching methods.

Boitshepo chose teaching as a career so that he could contribute to the development of human resources in the country. He loves being able to "instil knowledge in the students and produce great people in the society" (Boitshepo). Although he is motivated by pastoral roles in his job, he understands that "effective teaching also entails constant research and varying of teaching methods". Boitshepo believes that maximising learning can be done through "student centred methods such as; research, group discussions and presentation". Teaching, according to Boitshepo, involves using different teaching strategies to enhance learning.

Boitshepo believes a teacher should,

> "… make students aware of the problems faced by their environment encourage them to use of the skills acquired to fully participate in the conservation and protection of the environment." (Boitshepo)

According to Boitshepo, effective teaching in EE entails equipping students with the knowledge and skills to enable them to protect the environment. He also asserts that the teacher has to be "environmentally friendly, aware and understanding the different aspects of the environment" (Boitshepo) in order to effectively teach EE.

PCK as demonstrated in Boitshepo's CoRe

Curricular Saliency

Boitshepo was able to provide content to be addressed, especially for the Big Ideas A, B and D (see Appendix R). The content that he had initially placed under Big Idea C, which is on damming of water sources was more suited for Big Idea B; hence it was re-allocated there. Although he provides reasons why the students should learn about the Big Ideas, he does not convincingly justify the importance for learning about them, especially for Big Ideas A, C and D. The reasons he gives for the importance of the topic in Big Ideas A, C and D do not include reference to conceptual scaffolding or sequential development of understanding of other topics in the subject. For example, in Big Idea C, he states that it is important for students to learn the Big Idea because "water flows from high land to low land" while in Big Idea D, he states that "pollution affects water resources negatively". These sound more like ideas subordinate to the Big Ideas.

Boitshepo provides knowledge areas that he wishes to leave out for all the Big Ideas; this does not adequately demonstrate that Boitshepo understands what comes before and after the topic in hand. This is illustrated by his response in the questionnaire when he states that students need to know about management and conservation of the environment, the water sources and strategies being used to conserve water and the impact these strategies have on water resource management, all of which form part of the content to be included in the Big Ideas, especially Big Idea B. Boitshepo also mentions that "apart from domestic, industries and agricultural activities water can be used for economic purposes", (see Appendix R, Big Idea A) which may imply that he does not see agricultural and industrial activities as economic. The content therefore does not demonstrate a sound understanding of topics beyond what students need to know; hence Boitshepo's curricular saliency seems to be limited.

Content representations

Boitshepo identifies correct subordinate ideas but does not include problems of water storage, such as topography and evaporation, under Big Idea B. In the lesson plan, he proposes using a textbook and a poster although he does not elaborate more on the poster and how he intends to use it. Overall, his content representations are limited.

What is difficult and what is easy?

Boitshepo states that "indigenous knowledge on human activities, water conservation and the flow of river" (see Appendix R, Big Ideas A, B & C) make the topic difficult to teach. It is not clear what this indigenous knowledge is and how it limits or restricts the learning of the Big Ideas.

Boitshepo identifies "lack of resources" as another factor that may influence the teaching of the topic. This is only representative of the contextual constraints, hence his score on what is difficult and what is easy is limited.

Student prior knowledge including misunderstandings

Boitshepo does identify possible students' perceptions, misunderstandings and prior knowledge across all the Big Ideas. For example, he states that students perceive that "water is not scarce" and illustrates that this misconception is common among students who come from the wetland areas with plenty of surface water (see Appendix R, Big Idea A). Boitshepo is therefore aware of students' needs and considers their context and diversity. He further states that students think that there is or will be plenty of water in dams, rivers and boreholes, as long as there will be other rainy seasons (Big Idea A and D).

In Big Idea D, Boitshepo identified students' attitudes as influencing the teaching of the topic, thus showing basic PCK in terms of the rubric with regards to student prior knowledge, including misunderstandings**.** He stated that students had "attitudes of throwing things in water" and that the "students are familiar with pollution and how it can affect life".

Teaching strategies

Boitshepo provides a limited list of various teaching procedures which include mainly group discussion, class discussion and pair work, but does not provide reasons for choosing these. According to him, the reason for using class and group discussion is so that the students can come up with different ideas. There is no evidence in his CoRe of acknowledgement of student prior knowledge and misconceptions, nor aspects of curriculum saliency, such as corresponding subordinate concepts in a topic, sequencing for scaffolding learning and awareness of the background concepts needed before teaching the topic. Although the teaching strategies seem student-centred, the teaching strategies are not topic-specific and they provide few opportunities for student development.

6.2.3. A portrait of Felicia

Felicia, a diploma in secondary education graduate with a Social Studies specialisation, has taught in different Junior Secondary schools for about twenty years. She had no background training or in-service training on ecology, environmental studies or EE teaching until she enrolled at the University of Botswana for her Bachelor degree in secondary education in 2010.

Felicia stated that she was motivated to be a teacher by the desire to contribute towards imparting knowledge and skills to students. She believes that effective teaching entails “proper planning, use of teaching aids, reading widely and attending in-service workshops”. She perceives the “use of varied teaching activities” as a way of maximising learning and enhancing classroom participation.

According to Felicia, an effective EE teacher teaches “… for, in and about the environment. Objectives of EE should always be at the finger tips.” She considers that the teacher should have an “understanding of the environment and its concepts and the love for a friendly environment” (Felicia). Felicia does not elaborate well on what teaching for, in and about the environment really entails, according to her understanding.

PCK as demonstrated in Felicia's CoRe

Curricular saliency

Felicia identifies content that is necessary for the Big Ideas, although there is a lot provided for Big Ideas A and B and nothing for Big Idea C. The content for Big Idea B sounds more developed than other ideas (see Appendix S), indicating a more developed understanding. The initial content for Big Idea C had to be re-allocated to Big Idea B. Felicia's main reasons why students should learn the Big Ideas: understanding and appreciation of the importance of water and rainfall patterns, participation in water conservation and positive attitudes towards water. These positive attitudes include valuing water as an important and scarce resource, conserving water and avoiding pollution.

The response for why it might be important to know Big Idea C (that water can be transported from one region to another) is that "people look up to rain to bring water" (see Appendix S, Big Idea C). This implies that people don't necessarily see the possibility for water transfer. Felicia does not clearly show how this could possibly be a source of confusion. The reasons given for the importance of the topic are more on the affective and less on the cognitive aspects of learning, hence they exclude conceptual considerations, such as scaffolding and sequential development of understanding for other topics in the subject – limited, according to the rubric.

Content representations

Although Felicia was able to probe some of the Big Ideas (see Appendix S, Big Ideas A, B and D), she provided limited examples and explanations of specific links to the concepts she presented. As for the other few instances for Big Idea B, not many have explanations and examples, and those that are given are also not that elaborate. Despite mentioning the use of charts, posters and work cards in her lesson plan, she does not explain how these would be used to enhance student understanding and effective teaching.

What is difficult and what is easy

Felicia left spaces and does not give reasons for Big Ideas A, B and D but identified a difficulty: "limited knowledge of topography" (Felicia's CoRe Big Idea C). However, she did not elaborate whether the limited knowledge was the teacher's or the student's. She also does not specify how the identified sub-concept is problematic. The other factors that she identified as influencing the teaching of the Big Ideas are more logistical than contextual or conceptual.

Students' prior knowledge including misunderstandings

Felicia is able to identify some of the students' misunderstandings on three Big Ideas, that they think that water is plentiful, cheap and that they do not feel accountable for any water they waste (see Appendix S, Big Ideas A, B and C). She gives the reasons for the students' prior knowledge, especially for Big Idea B where she is specific about wastage by students, e.g. "students see the task of Government building of dams so that they can continue to have water flowing in their taps" and "they don't feel they are accountable for water wasted in their homes, community standpipes and at school" (see Appendix S, Big Idea B). These perceptions are directly linked to the Big Idea that 'although water is a renewable resource, the amount of usable water available is limited by how much can be stored'. Her knowledge of the students' prior knowledge, including misunderstandings, was scored as basic on the rubric.

Teaching strategies

Felicia lists a group of teaching procedures like class discussions, group discussions, lectures, video clips, mini research projects, panel discussions (see Appendix S, Big Ideas A, B, C and D), to encourage students to work as teams to fight the environmental issues facing them, share ideas and allow for the development of problem-solving skills and participation. Big idea B seems to be the only one with a more developed and specific strategy as compared to the other ideas. Although the teaching strategies seem varied and possibly allowing for opportunities for student development, there is no evidence of acknowledgement of student prior knowledge and misconceptions. There is limited evidence of corresponding subordinate concepts in a topic

or sequencing for scaffolding learning; awareness of the background concepts is also needed before teaching the topic.

6.2.4. A portrait of Irene

Irene has taught Social Studies at Junior Secondary schools for the past 14 years. She states that prior to her enrolment at the University of Botswana for the BEd, she had not received any training on environmental studies or EE methods.

Irene "loved working with students after teaching at Tirelo Sechaba", a National Service Programme in which all Botswana citizens are expected to participate. She therefore decided to become a teacher on completion of the programme. She says she loves her job,

> "… because of the trust bestowed by the students on me, the ability to change their lives and being there for them in all ways as well as guiding and shaping them" (Irene).

Irene argues that student-centred activities, a democratic classroom, good rapport with students, humour, regular exercises and feedback help to maximise learning. She asserts that "real concern for the environment, reading widely and being knowledgeable on contemporary issues" (Irene) enhances effective teaching of EE. Furthermore, she emphasises the importance of teaching in accordance with the aims of EE, i.e. awareness, knowledge, attitudes, skills and participation (AKASP). She further states that "dedication and pedagogical knowledge" (Irene), are important for effective teaching of EE. She describes pedagogical knowledge as "… appropriate teaching methods for EE."

PCK as demonstrated in Irene's CoRe

Curricular saliency

Irene provides a list of the content intended to be covered under each Big Idea. She probes each Big Idea for the relevant content (see Appendix T, Big Ideas A, B, C and D). It is evident that Irene probed Big Ideas A, B and D; they seem more developed than C. The reasons she provides for the importance of the topic include conceptual considerations, such as

scaffolding/sequential development of understanding for other topics in the subject. For example, she argues that the content for the Big Ideas B, C and D she specifies as important in helping students gain knowledge and awareness (on dam water capacity, expenses incurred in water transfer schemes, climate change, sustainability, water distribution and availability) develop conservation skills, help to appreciate the importance of water, develop a sense of responsibility, and change their attitudes towards water sustainability. These link very well with the intended content she provided. This suggests a developing PCK on curricular saliency, according to the rubric.

Content representations

There is evidence of explanatory notes to make the links to the aspects of the concept being explained, especially in Big Ideas A, B and D. The exception is for Big Idea C which seemed less developed. Irene also proposes to use charts and a textbook in her lesson but does not adequately describe how she uses these to achieve the objectives of the lesson; hence her content representations are limited.

What is difficult and what is easy

Irene identifies difficulties that are connected to the teaching of the Big Ideas. These are more contextual, cognitive and to do with the attitudes of the students. Thus the reasons are more conceptual and move beyond logistical constraints. She states that:

> "Students may take availability of water for granted if they live in an area of good water supply hence difficult to be convinced that water is a scarce resource" (Irene's Big Idea A)

Here it is the attitude which makes the learning of the topic difficult. Furthermore, Irene argues that "Students may fail to understand why enough water cannot be stored or why there can't be enough storage resources", which is a failure to grasp a concept like damming. Thus she is able to identify a specific cognitive challenge related to prior knowledge of students on a Big

Idea (Big Ideas A and B). Despite not identifying the possible sources of confusion, she demonstrates sound understanding of topics beyond what students need to know, and will get a score of basic according to the rubric.

Students' prior knowledge including misunderstandings

Irene manages to identify students' prior knowledge and misconceptions across all the Big Ideas and each is specific to the Big Idea, thus providing the basis and reasons for the consistent students' knowledge. She acknowledges what her students know, for example that "domestic water is essential for use" (see Appendix T, Big Idea A). She also indicates that the students have some points of misunderstanding or "myths" with regards to water issues. For example, she states that "Students do not seem to understand that usage of water affects the capacity at source" (Big Idea B). This shows that she has some developing knowledge of her students' prior knowledge and traditional belief systems.

Irene also demonstrates awareness of students' needs and considers their context and diversity, and this is exemplified in her awareness of the impact of the different traditional and religious beliefs of the students that may influence their thinking in learning about the particular Big Ideas (see Appendix T, Big Ideas B and C).

Teaching strategies

Irene perceives that the appropriateness of the teaching methods for EE and the context in which the students are learning influences their understanding of the Big Ideas, so in her CoRe, she provides a variety of teaching and assessment procedures for the different Big Ideas. Each procedure is used to fulfil a certain objective. For her, the teaching procedures are important to help solicit wide and quality responses, and involve the students in the learning process. She also believes that student-centred activities, democratic classrooms, good rapport with students, humour, regular exercises and feedback help to maximise learning.

In her CoRe, Irene provides her students with various activities such as group discussions, mini–research, mini-reports and reflection papers. She states that the mini-projects "fully

involve students and ensure they link with the environment and expose the malpractices and water mismanagement in hands on activity" (see Appendix T, Big Idea D). She chooses to use a group research project and presentations for Big Idea A; mini projects, reports and reflection papers specific to the content for Big Idea D; the video on water transportation links to the content for Big Idea C; and the teaching strategies align to EE learning. This illustrates a developing PCK, according to the rubric.

6.2.5. A portrait of Kagiso

Kagiso has taught Social Studies for a period of about fourteen years in different Junior Secondary schools in the country. He has a diploma in secondary education, as well as a certificate in library and information systems. He has also served as a school librarian and facilitated library and information studies in the schools for about six years. He did not get any kind of training in environmental studies or environmental education before his enrolment for the BEd at the University of Botswana in 2010.

Kagiso loves teaching because it makes him "a continuous student and enables him to acquire more skills in dealing with new challenges and exploring new areas of information" (Kagiso).
Effective teaching according to Kagiso entails:

> "good knowledge of the content, the use of varied methodologies, understanding of the needs of the students, use of proper teaching and learning aids as well as passion for the job"(Kagiso).

Unlike the other respondents, Kagiso believes that learning can be maximised by "giving students tasks that challenge them to explore information and make conclusions and decisions or solve problems" (Kagiso). He believes that this

> "... ensures that they participate actively and make additional contribution, question the content and see clarity in what they are learning" (Kagiso).

An effective teacher in EE, according to Kagiso, should be "passionate about the subject and the environment, knowledgeable and enthusiastic, hands on, leading by example and make the

learning of EE practical." These adhere to the characteristics for effective teaching of EE as identified by the respondents in the data.

PCK as demonstrated in Kagiso's CoRe

Curricular saliency

Kagiso provides content across the Big Ideas, although some of them seem to show more probing than others. Big Ideas A, B and D were adequately populated while, for Big Idea C, more content such as run off, transfer schemes and water protocols could have been included (see Appendix U, Big Idea C). Kagiso indicated that students needed to know the following before they could understand the topic Water Resources and Management: the consequences of their actions on water wastage; knowledge of where water is sourced and what is involved to ultimately get clean water piped into their compounds; and an understanding of their relationship with water resources, i.e. how water resources are of importance.

He states that the students need to understand the content so that they can acquire skills, knowledge and understanding of the importance of water conservation and waste management, and can participate in water conservation. Kagiso's reasons for the importance of the topic exclude conceptual considerations, such as scaffolding/sequential development of understanding for other topics in the subject. He does not identify possible sources of confusion, hence his curricular saliency seems to be limited**.**

Content representations

In his CoRe, explanatory notes are used to make the links to the aspects of the concept being explained. He provides some explanatory notes and examples for two concepts to show what they entail: for 'ways of conserving water resources' (see Appendix U, Big Idea B) and 'ways of reducing pollution' (see Appendix U, Big Idea D). He proposes to use work cards, posters and a video on being water-wise. However, he does not adequately show how he uses these to enhance the effective teaching of the topic. This suggests that Kagiso has a limited PCK, according to the rubric.

What is difficult and what is easy

Kagiso notes some difficulties that could limit the teaching of the Big Ideas. An example is in Big Idea D, where he states that "in areas with less generation of waste, it may not be easy convincing pupils about water contamination." He makes a link between waste and water contamination but perceives that his students may not grasp this association. Most of the reasons he provides seem more attitudinal than cognitive, hence addressing only the context rather than the conceptual. Examples include the problem of failing to convince students of the importance of water, especially if they have easy access to water and have little concern for water conservation. This boils down to students' attitudes towards water sustainability.

Students' prior knowledge including misunderstandings

Kagiso gives examples of misunderstandings the students have on all the Big Ideas and argues that this may influence the teaching of the Big Ideas, although he does not explain how it does. These misunderstandings are mostly around students' lack of knowledge on water shortage in the country, especially in the rural areas. Kagiso takes into consideration how the diversity of the students (rural vs. urban) can influence their understanding on water shortage in the country (see Appendix U, Big Idea B). These considerations are basic on the rubric.

Teaching strategies

Kagiso outlines the teaching strategies for all the Big Ideas and provides justification for the procedures he chooses for Big Ideas A and B. His teaching strategies include mini-projects, group work, video watching, group discussions, site visits and investigations. He states that he chooses these so as to "allow for sharing of ideas among his students and to enable effective participation" (Kagiso's CoRe Big Idea A). He gives strategies such as class exercise, quizzes and assignments and does not include their likely range of responses.

He was able to provide various teaching strategies, such as group discussions, site visits and investigation projects. He believes that maximising learning in EE involves giving students practical and hands-on tasks that challenge them to explore information, and make conclusions

and decisions or solve problems. An example of the teaching strategies he provides is, for Big Idea D, investigation, which allows his students to explore facts and find information, thus enhancing "student knowledge and insight on the problem, improve attitudes … as well as sound decision making" (see Appendix U, Big Idea D). This strategy is also more practical. It fits in with Kagiso's understanding that learning in EE should include "giving students tasks that challenge them to explore information and make conclusions and decisions or solve problems" (Kagiso's CoRe Big Idea A). He states that this "ensures that they participate actively and make additional contribution, question the content and see clarity in what they are learning," hence his choice of the teaching strategies for the Big Ideas in the CoRe. Despite his provision of the vast teaching strategies, most of them are not very elaborate, hence the basic score on the rubric.

6.2.6. A portrait of Naledi

Naledi has taught Social Studies for a period of about fifteen years in different Junior Secondary schools in the country. She has a diploma in secondary education, specialising in Social Studies and Setswana. She taught Setswana for a few years before ultimately sticking to Social Studies. Unlike her colleagues in the focus group, she has attended in-service training workshops on environmental studies or environmental education.

Naledi's love for teaching is so that she can "help young people realise their dream through education." According to Naledi, a teacher requires:

> "... thorough knowledge about the subject, knowledge about the diversity of the students so as to help the teacher choose and vary their methods of teaching, to involve students in their teaching as well as having the teachers work well organised through good planning." (Naledi)

She sees the teacher as a social worker:

> "… the teacher is loco parentis to the students. Our students come from different social backgrounds and the teacher has to be there as a counsellor to those who need

counselling. The teacher also has to attend to the social needs of the student so that they can perform well in class." (Naledi)

She believes that, by using different methodologies that are student-centred and allow for students to be actively engaged in the learning process, such as group work, debate and individual assignments, learning is maximised.

She argues that for one to teach EE effectively, there is need to have "passion for environment, in-depth understanding of the environment as well as a positive attitude" towards the environment. She further states that the teacher needs to understand the importance of teaching,

> "… about the environment, for the environment and teaching in the environment; understand the values and ethics of EE so that the teacher promote value clarification; understand different theories on approaches to the teaching of EE so that the teacher can promote effective understanding by using appropriate approaches. The teacher also needs to understand the diversity of the students themselves and the complexity of knowledge." (Naledi)

PCK as demonstrated in Naledi's CoRe

Curricular saliency

Naledi provides a broad scope of the content to be covered for the different Big Ideas. She includes specific content to be covered under each Big Idea except that she misses the points on agricultural uses under Big Idea A, damming for Big Idea B and transfer schemes for Big Idea C. She gives a variety of reasons why it is important for her students to learn the Big Ideas. These include promoting awareness and understanding, and engaging students in educating the community. It is apparent from her responses that Naledi believes that the content should enable students to reflect on their actions, change their attitudes and actions, and take deliberate action towards their environment, thus helping them connect with the environment in a positive way (see Appendix V, Big Ideas A, B, C and D).

Naledi states that students need to know "the sources of water resources in Botswana and the factors affecting water resources" before they can understand the management and conservation of water resources. She explains that it is important for students to learn about the management and conservation of water resources so as to "create awareness and promote understanding which will hopefully promote positive attitude towards the environment." Thus, she is perceptive of what the students need to know in order to understand another concept,

She states that she intends to leave out content on the "issues of climatic change and response from developed nations on climatic change" (see Appendix V, Big Ideas C and D), "global issues and debates on conservation" and also about "pollution of water by mercury that escapes from bulbs used in homes" (see Appendix V, Big Idea D). It is not clear at this point if she is referring to air pollution or water pollution. She also knows about some on-going research which she says "may mislead her students" (see Appendix V, Big Ideas A, B and C), but she does not specify what that research is about.

Content representations

In Big Ideas A, B and D, she identifies the content area, and also gives some explanatory notes and examples that link the representation to the aspects of the concept being explained. Naledi mentions the use of posters and work cards but without adequate explanation as to how these are used to aid the lesson, hence her basic score on the rubric.

What is difficult and what is easy

Naledi identifies a number of difficulties or limitations connected with teaching the Big Ideas (see Appendix V, Big Ideas A, B, C and D). Most of the reasons she identifies are representative of contextual constraints, for example: language barrier, regional variation of students and the proximity to areas used as examples in class. There are also difficulties, such as curriculum design, resources, time-table constraints and political frameworks which tend to be more logistical. Nevertheless, Naledi identifies challenges that seem more conceptual, such as "lack of knowledge of some concept" and the "traditional knowledge and methodologies used by

teacher" that "do not promote diversity in dealing with environmental issues" as constraints and limitations to the teaching of the Big Ideas.

Students' prior knowledge including misconceptions

Naledi displays a developing PCK in that she identifies the things that the students already know, such as the uses of water and the importance of water to people. She also notes some misconceptions that the students may have, based on their values and beliefs. An example of the latter is that "water is from God" (Naledi's CoRe, Big Idea C). Traditional beliefs include rainmaking and praying for rain (see Appendix V), which she perceives may limit or influence the students' understanding of the concept.

She states that her students have a misunderstanding that water is a renewable resource and it can be replaced. This makes children think that no matter how they use water, it will reappear. She observes that students' beliefs connected to water usage and supply may contribute to such misunderstandings. Naledi also notes that some students come from rural areas where water is scarce and sometimes they travel long distances to get it, hence these students may realise the importance and value of water easily. Thus she identifies the role that the context in which the students find themselves may influence their understanding of the topic.

Teaching strategies

For each Big Idea, Naledi identifies the teaching strategies and provides justification for some of the teaching procedures she chooses. The teaching strategies include lectures, videos, group discussions, class debates and individual work. She chooses these so as to promote awareness and knowledge, attitudinal change, and also allow for sharing of ideas among her students through interacting with each other. Naledi is very committed to promoting conservation (Big Idea B), so she specifically chooses to engage students in mini-projects so that she can promote the conservation of water resources, and a positive attitude towards the environment that will, in turn, influence them to become custodians of a safer environment and have positive mind-sets on water usage. Unlike the other teaching strategies that seem more

generic, the mini-projects she chooses to use to engage students on conserving water resources are more specific to the Big Idea, thus displaying a developing PCK.

6.3. Teachers' PCK as manifested in lesson plans

Loughran et al (2006) suggests that the CoRes may be limited in terms of providing insights about teachers' PCK, hence his use of Pedagogical and Professional Experience Repertoires (PaP-eRs). Since the analysis of teachers' CoRes revealed little evidence of teachers' PCK and also considering the fact that the topic on Water Resources and their Management is new as a stand-alone topic in the Botswana revised 3 Year Junior Certificate Social Studies syllabus of 2009, I further explore the potential of other sources that teachers may draw on to support their construction of topic-specific PCK. I consider sources such as lesson plans, textbooks and the EE methodology course the participants in the focus group were studying. In the lesson plans, I explored how the participants transformed underlying content knowledge of Water Resources and their Management into teachable content knowledge. Since "teaching involves an exchange of ideas, the teacher must grasp, probe and understand the idea, see its many sides, shape and tailor it until it can be understood by the student" Shulman (2004, p. 234), I explore their thinking, reasoning and actions in teaching about water resources management and conservation in Botswana.

I examined five lesson plans developed by the teachers in the case study group to create a picture between knowledge and understanding versus their thinking about effective planning and teaching of environmentally-oriented topics. The participants used the adapted Wits Rationale for Lesson design template (see Appendix O) to develop their lesson plans. Although the lesson plan format was new to the respondents, they were familiar with most of the components in the rationale for the lesson design template, as they had previously worked with the CoRe template which contained similar components. Lesson planning is a much more familiar activity for the teachers, so it was thought that they may articulate some of their intentions better in a lesson plan than on the CoRe template. This template, according to

Rusznyak & Walton (2011), is also a Lesson Planning Guideline that intends to scaffold teachers' PCK. The template compels the teachers to

> "… consider the purpose of their lesson, articulate their understanding of the content knowledge to be learnt, reflect on the students for whom the lesson is intended and the ways in which they might engage with the content knowledge and, finally, substantiate their choices of the teaching and learning strategies that could be appropriate in light of the previous considerations" (Rusznyak & Walton, 2011, p. 275).

The respondents picked one of the Big Ideas as the theme of their lesson design, selected a topic that would be suitable for the theme, and designed a lesson plan on it. I therefore use the lesson plans as a data source to explore the extent to which the teachers' plans are coherent with the purposes of the lessons, their interpretation and representation of the content, as well as the selection, adaptation and tailoring of their teaching strategies to suit the needs of the students and the nature of the topics being taught.

It was interesting to note that all the respondents decided to develop a lesson plan on the sub-topic water conservation and water management strategies. This topic falls within Big Idea B, that states that "although water is a renewable resource, the amount of usable water available is limited by how much can be stored". It was evident in the CoRes that Big Idea B was the best developed idea from the CoRes for all the respondents. The reasons for choosing water conservation for lesson planning could be that the teachers find the topic easy to understand, important, more familiar and accessible to students and easier to relate to, considering the recent appeals by the Botswana Water Utilities Corporation to use water wisely. This section compares the lesson plans for all the respondents, identifies patterns and deduces what these could suggest.

The articulated purpose of the lesson

The purpose of the lesson was generally well expressed by all the respondents (see summary, table 7.1). The respondents were able to identify the key questions, the skills they intended to develop, and the desired attitudes and values they wanted to promote.

Table 6.3. Summary response on the purpose of the lesson

Respondents	The purpose		
	Key questions	**Skills**	**Attitudes and values**
Boitshepo	- Defining conservation - Identifying water conservation strategies	- Participation in water conservation	- Value water as an important and scarce resource - Sustainable use of water
Felicia	- Name water sources - Identifying and assess water conservation strategies - Make observations on water wastage	- critical thinking skills - Participation in water conservation	- Value water as an important and scarce resource - wise use of water
Irene	- assess the factors affecting water conservation - investigate major sources of pollution	- critical thinking and research skills	Blank
Kagiso	- assess water conserving practices - investigate factors affecting water quantity and quality	- critical thinking and research skills	- accountability and willingness to participate in water conservation
Naledi	- Identifying water conservation strategies	- critical thinking and analytical skills	- appreciation of water as an important and scarce resource - positive mind-set on water usage

The most common key question amongst all the respondents entailed identification and assessing of water conservation practices in Botswana, which blends well with the topic chosen. Also included were key questions that seemed to deviate from conservation; for example, Irene includes a key question on the major sources of water pollution while Kagiso wants to initiate and investigate factors affecting water quality but is not specific as to what water quality would mean. The key questions posed by the respondents showed different cognitive demands. Boitshepo and Naledi's key questions revolve around knowledge and comprehension only, while Felicia, Irene and Kagiso include higher-order cognitive questions that include evaluation and investigation. EE promotes learning that encompasses all the cognitive levels: knowledge, comprehension, application, analysis, synthesis and evaluation (Bloom et al, 1956), allowing students to also apply what they have learnt to real life.

Boitshepo and Felicia nurture participation among their students with regard to conservation. Participation is notably one of the key goals of EE. Irene, Naledi and Kagiso further include critical thinking and research skills as important to develop among the students. Naledi also adds analytical skills to the list. The respondents aim at promoting the appreciation and valuing of water as an important and scarce resource, as well as wise and sustainable use of water. These echo the teachers' belief that effective teaching entails commitment to environmental wellbeing, as previously expressed in chapter five.

Content knowledge for lesson

Some exemplar content that one would expect teachers to consider when teaching about conservation would include: challenges with water availability and storage as per the National Water Master Plan (rapid water increase demand in Botswana, challenges of developing surface water resources, low recharge rates of underground water, poor quality of water, high evaporation) and the various water conservation practices in Botswana (reduced consumption, reuse of waste water, rainwater harvesting, water rationing, water education). The concepts and content provided across all respondents are vaguely articulated. Kagiso and Irene did not provide any content to be covered by the topic in the section for content knowledge for the lesson. Boitshepo, Felicia and Naledi make an attempt to provide the content area, although they do so very briefly.

Water conservation strategies are included by Boitshepo (recycling waste water, rainwater harvesting), Felicia (reduce, reuse and recycle, strict water charges, enacting laws/policies, construction of dams, public education and awareness) and Naledi (water restrictions/tariffs, reduce, reuse and recycle, educational awareness). The content by the three respondents, especially by Naledi and Felicia, is similar. Although there was inclusion of valid concepts by the participants, some were also omitted. Felicia includes content on "construction of dams" which does not seem very appropriate or connected to the topic to be taught. This could suggest that she lacks content knowledge on the topic to be taught or there is confusion and a mix-up of the Big Ideas. Since the ability to "engage in pedagogical reasoning, rests on teachers'

understanding of the content knowledge they teach" (Rusznyak, 2009, p. 123), if the content knowledge is not adequate and suitable for teaching, then effective teaching may be compromised.

Curricular saliency

All the respondents were able to indicate the topic that came before the one to be taught. They manage to position their lessons within sequence. Although all the respondents plan for the topic Water Resources and Conservation, some of the respondents tend to have a mix of two Big Ideas (conservation and pollution) in one lesson plan. The teachers seem to be unable to judge the depth to which a topic should be covered and the amount of time to be spent on it (Mavhunga & Rollnick, 2011). For example, unlike the other respondents, Irene, Kagiso and Naledi were also not able to appropriately match the theme for the lesson with the topic; they chose the theme of water pollution and thereafter prepared a lesson on water conservation. Lesson plans developed by Boitshepo, Felicia and Naledi stuck to water resources and conservation, persisting with one Big Idea at a time, while Irene and Kagiso switched between more than one Big Idea in one lesson. Kagiso also includes both water quality and quantity in the purpose of the lesson, thus confusing water quality and quantity issues. It is knowledge of curricular saliency that enables a good teacher to judge matters, such as depth of treatment and contextualisation. A problem with curricular saliency may inhibit the teacher from recognising features and patterns that are potentially important for improving instruction. They fail to provide students with learning activities that enhance their ability to make meaningful patterns of information and develop their confidence and competence.

Student factors to consider in relation to the topic

Some of the student factors to consider, as stated by the respondents, included: students' attitudes that water is plentiful (Boitshepo), students coming from different cultural backgrounds and having different learning abilities, students' prior knowledge of the importance of water in their daily lives and their different beliefs and geographical backgrounds (Naledi). This is an indication the teachers are aware of the students' prior knowledge and some

of the factors that can influence the learning of the topic. Therefore it is possible for the teacher to determine what information will be selected for attention. Since the teachers have an insight into their students' prior knowledge, expectations and perceptions, they should be able to design learning activities that will challenge the existing conceptions, such that students can reconstruct their personal theories (Cakir, 2008). Although Boitshepo, Kagiso and Naledi identified these factors, they did not elaborate or suggest how these factors could possibly affect the learning of the topic. There was no further indication in the lesson plan how these factors were incorporated to show the way the respondents would work with them to enhance student understanding.

Teaching and learning strategies

The lesson plans developed by Felicia and Naledi try to stick to water resources and conservation, thus one Big Idea at a time. Naledi attempts to be more specific in her lesson steps, compared to the other respondents. She describes in detail what will happen in each lesson step or each learning activity. In spite of having done the CoRes, the teaching strategies are still vague and generic. The dominant teaching strategies are group discussion and presentations for all the respondents. Although some, such as Felicia, Irene and Kagiso indicate in their teaching strategies that they would use investigations and a mini-research project, none of these are reflected in the lesson steps (see table 7.2). The teaching strategies do not seem to encourage the skills that the respondents alluded to in their purpose of the lesson, namely: participation, critical thinking and analytical skills. For those who had previously prioritised reading tasks like Felicia and Naledi, there is no evidence of this in their lesson plans. Some of the respondents like Felicia, Irene and Kagiso included teaching strategies they had not previously mentioned to try and strengthen the lesson. For example, Felicia added presentations to the lesson steps, Irene included listing and explaining while Kagiso included the lecture method. Despite these additions, the teaching strategies still seemed to be mostly generic and not specific to the needs of the students and the nature of the EE topic.

There is a variety of teaching and learning approaches in EE but most importantly they should nurture all the goals of EE, i.e. AKASP. This can be achieved through learning ***about*** the environment, ***in*** the environment and ***for*** the environment. Most of the suggested teaching and learning strategies were ***about*** the environment while none were ***in*** or ***for*** the environment. This suggests that discussions and presentations which are dominant in the participants' teaching strategies may not be adequate to fulfill the goals of EE. More consideration should be given to learning ***in*** and ***for*** the environment. This would mean also including teaching activities that promote inquiry-based learning, such as field studies and site visits, investigations into the environment, problem-solving, gaming and simulation, role play, case studies and survey researches.

Table 6.4. Summary responses on teaching strategies and lesson steps

Respondent	**Teaching strategy**	**Lesson steps**
Boitshepo	Group work, class discussion and brainstorming ***(about)***	Group work, presentation, oral questioning, summary by teacher
Felicia	Video clip, group discussion, reading, quiz and mini-research project ***(about)***	Video, groups with charts, presentation and stress of main points, evaluation exercise, but none of the questions in the quiz are connected to the topic of the lesson.
Irene	Group discussion, presentation and project ***(about)***	Listing and explaining, group discussion, presentation, evaluation exercise, recap by students
Kagiso	Group discussion, video showing, investigation and project ***(about)***	Group discussion, video & posters, questioning students
Naledi	Lecture method, group discussion and presentation ***(about)*** (Class exercise, oral questions and answers).	Group discussion, presentation, exercise (not specified), asking reflective questions

In the lesson steps, the only variation noted is on the evaluation of the students' understanding. Boitshepo, Kagiso and Naledi opt for questioning the students; Felicia prepares a quiz as an evaluation exercise, but none of the questions are connected to the topic of the lesson. Irene gives her students an exercise from a Social Studies textbook and out of the five multiple-choice questions that make up the evaluation, only two are relevant to the topic taught.

In the next section, I move from the teachers' lesson plans to another possible source of PCK for the teachers, that is, textbooks. As mentioned earlier in the chapter, I explored the content in the three extracts on the topic Water Resources and Management, as well as the PCK components of curricular saliency, content representations, what is difficult to teach, student prior knowledge and the conceptual teaching strategies.

6.4. Content knowledge in the textbooks

The content in the textbooks was mainly focused on the importance of water, the sources of water, the factors affecting water resources in Botswana and water conservation practices in Botswana. There was no content on the importance of water and water sources in Gatsha and Ngongola (2009); the two textbooks, Ford et al (2009) and Mpitse et al (2009) covered more content. The main ideas or Big Ideas as identified in the texts included: importance of water, water sources, factors affecting the water sources and conservation practices in Botswana. Although these Big Ideas are not identical to the four that I formulated for the topic Water Resources and Management, some of the content, as provided in the extracts, does fit.

Below I describe the content in the textbook extracts in relation to the Big Ideas formulated for the study. These Big Ideas include:

A. Many human activities depend on access to water (*usability of water*)
B. Although water is a renewable resource, the amount of usable water available is limited by how much can be stored (*quantity and management*)
C. Water can be transported from one region to another (*management and distribution*)
D. Water pollution can decrease its usability (*quality and management*)

Table 6.5. Summary of the content knowledge in the textbook extracts

Textbook	***Content***	***Big Idea emphasised***
Ford, R., Mlambo, A. & Mosetlhi, S. & Ndaba, V., (2009). ***Exploring Social Studies, Form 1*****, Heinemann**	➢ Why water is important?	***Big Idea A*** Many human activities depend on access to water *(usability of water)*
	➢ **Sources of water** * <u>surface water</u> - rivers (perennial rivers in the north and far from majority of the population in eastern Botswana where demand is high) - pans (main water source in the western (driest) part of Botswana, usually salty, and only contain water after heavy rains) - dams (Letsibogo the largest, supplies Phikwe and other parts of Southern Botswana where there is little water Problems with dams: ▪ dam walls affect river's natural flow , so sometimes leads to flooding during heavy rains ▪ high temperatures may cause high evaporation in the dams ▪ reduction of depth of dam due to large river deposits of sediments on the dam floor ▪ pollution of dams from various human activities - inland deltas - lakes - <u>underground water</u> ▪ main water source in Botswana ▪ large water quantities of water underground as a result of infiltration - water pumped to surface through borehole drilling (good quality unlike the salty water from wells	***Big Idea B*** Although water is a renewable resource, the amount of usable water available is limited by how much can be stored (*quantity and management*)
	➢ **water conservation** ▪ definition of water conservation ▪ Botswana National conservation strategies (year found and main aims and main pressure areas, namely; population, development and urbanisation ▪ Water conservation methods: recycle, reduce, reuse and water harvesting; Reducing water consumption – water restrictions, education on conservation, price increases; reuse waste water	***Big Idea B*** Although water is a renewable resource, the amount of usable water available is limited by how much can be stored (*quantity and management*)
Gatsha, G. & Ngongola, V., (2009). ***Social Studies, A fresh start Book 1*****, Diamond Educational**	➢ **Factors affecting water resources in Botswana** ▪ Rainfall – low rainfall, seasonal rainfall, drought ▪ high temperature ▪ sandy soils ▪ location of perennial rivers (Chobe and Okavango located far from where people live so cannot be used for water supply) ▪ Water resources shared with other countries	***Big Idea B*** Although water is a renewable resource, the amount of usable water available is limited by how much can be stored (*quantity and management*) ***Big Idea C*** Water can be transported from one region to

Textbook	*Content*	*Big Idea emphasised*
Publishers		another (*management and distribution*)
	➢ **Water conservation practices in Botswana** - examples of ways of conserving water in Botswana (water restrictions, recycling, rain water harvesting, reuse of waste water, dry gardening)	***Big Idea B*** Although water is a renewable resource, the amount of usable water available is limited by how much can be stored (*quantity and management*)
: **Mpitse, D. L., Rampha, L. & Tsayang, T., (2009)**. ***Social Studies Form 1***, **Collegium**	➢ **Introducing water as an important commodity in Botswana**	***Big Idea A*** Many human activities depend on access to water *(usability of water)*
	➢ **Sources of water** ***** Surface water ▪ natural pans (Makgadikgadi, Ntwetwe, Okavango delta) ▪ depressions (Ntondola, Goloa) ▪ rivers – intermittent vs perennial rivers (examples and locations given in table) ▪ wetlands – Okavango delta (detailed description on where it starts and how it flows, its rich soils, water plans, different wildlife species) ▪ dams – description of what the dam is and how it is constructed, examples of dams in Botswana; the river along which they are constructed and the towns and villages near the dams provided in a table * Underground – extracted from pools and aquifers, boreholes drilled in identified points by hydrologists	***Big Idea B*** Although water is a renewable resource, the amount of usable water available is limited by how much can be stored (*quantity and management*)
	➢ **Factors affecting water resources in Botswana** ▪ Climate – arid and semi-arid; low rainfall that is erratic, unreliable and regional; rivers flow during rainy seasons and dry up during dry seasons; high evaporation due to high summer temperatures; little recharge of underground aquifers; western and southern Botswana receive lowest rainfall; dam construction difficult due to erratic run-off or flowing water ▪ Lack of proper dam sites – because of flat land (topography). Lots of water lost through run-off into rivers flowing away from Botswana	***Big Idea B*** Although water is a renewable resource, the amount of usable water available is limited by how much can be stored (*quantity and management*)
	➢ **Water conservation in Botswana** ▪ Causes of water shortage in many villages caused by drying dams; drying boreholes; low, unreliable, erratic rainfall; global climatic change ▪ Water conservation practices; dam construction, charges for water use, re-using, recycling, water harvesting (water from gutters and rooftops), desalination of salty water, education on water conservation strategies and recycled water	***Big Idea B*** Although water is a renewable resource, the amount of usable water available is limited by how much can be stored (*quantity and management*)

6.5. PCK in the textbooks

I also looked at extracts from the topic Water Resources and their Management in all three main Social Studies textbooks for the junior certificate level to explore PCK on water resources and management. This does not give any insight into the teachers' own PCK, but might give them access to the way textbook writers have used their content knowledge and PCK to transform topics into teachable materials. Thereafter, I briefly explored the EE methodology course for aspects of PCK that would have been made accessible to the respondents in the focus group.

I explored PCK in extracts on water resources and management from three of the Form one Social Studies textbooks. These were the main textbooks for Social Studies teachers and were made available to all five respondents who constituted the focus group of the study. The participants also had access to these textbooks when planning their lessons. I was particularly looking into curricular saliency, content representations, what is difficult to teach, student prior knowledge and teaching strategies. The evaluation of the textbooks showed that there are some PCK components that are more prominent than others. Curricular saliency, content representations and student prior knowledge were more evident while there were a few traces of topic-specific teaching strategies and what is difficult to teach about the topic.

Out of all the PCK components being explored, the most prominent was curricular saliency, where the textbooks were able to identify the Big Ideas and the corresponding subordinate concepts (see table 7.3) in a topic; some understanding of the purposes for teaching the topic and sequencing for scaffolding learning was shown. It is important to note that, although the textbooks identified their "Big Ideas", these were in accordance with the Junior Secondary Social Studies syllabus and not necessarily on the broad understanding of water sources and management, like the Big Ideas I developed for the topic. Content representations were also evident in Mpitse et al. (2009), where content was more detailed and explanatory, and illustrations in the form of maps, charts, tables and photographs were included. Gatsha and Ngongola (2009) used photographs to illustrate water conservation practices. Other PCK

components such as what is difficult to teach, student prior knowledge and teaching strategies were limited in the textbooks. Below I briefly describe the results of the evaluation and compare the textbooks.

Curricular saliency

All three texts were able to divide the topic into subtopics, and thus were able to identify the Big Ideas and the corresponding subordinate concepts in the topic. Gatsha & Ngongola (2009) only address two subtopics: the factors affecting water resources and the water conservation strategies in Botswana. The other two textbooks by Mpitse et al. (2009) and Ford et al. (2009) attempt to show how the topic fits into the curriculum by providing the background concepts needed before teaching the topic. The texts also show an understanding of the purposes for teaching the topic and sequencing for scaffolding learning. For example, all the texts start by introducing the importance of water and distinguish between surface water and ground water sources. Mpitse et al. (2009) is more in-depth on the content for the subtopics than Ford et al. (2009) and provides more subtopics to enhance understanding. The depth for the content on the water sources, the factors affecting water sources and conservation practices in Botswana are more comprehensive than in the other two texts (see table 6.5).

Content representations

The content in all three textbooks seems up to date, the descriptions and details are clear enough for students and free from factual and technical errors. Content is wide-ranging and more elaborate in Mpitse et al. (2009) than in the other two textbooks. The former includes photographs that illustrate water conservation strategies; they are well-presented and clarify what is presented in the text. There are more explanations and illustrations in the form of maps and tables in Mpitse et al. (2009) which further clarifies what is presented in the text.

What is difficult to teach?

Mpitse et al. (2009) provides an exercise where students are asked to explain why some rivers are perennial while some are intermittent. This may be an attempt to clear up conceptual

confusion between rainfall patterns in the country and water availability, and also to distinguish between rivers that flow seasonally and those that flow all year round, as well as the reasons for this.

The identified factors that influenced the teaching of the Big Ideas, those that made an idea difficult or easy to teach included knowledge of content, behavioural changes, logistical factors (resources, time-table constraints), attitudes and students' diversity and contexts. Students' context and diversity issues, such as traditional and religious beliefs (Irene and Naledi), as well as rural versus urban learning environments (Boitshepo and Kagiso), could influence the thinking and learning of students about water resources and their management. The difficulties identified by Irene and Naledi on Big Idea A, unlike those of the other participants, moved beyond logistical constraints and were more conceptual. For example, Naledi stated that "lack of knowledge of some concept by the teacher", could make the learning of the topic difficult. It therefore seemed that only Irene and Naledi were aware of the conceptual difficulties that may have made the topic difficult to teach, while Felicia and Naledi identified the logistical challenges to teaching the topic and Kagiso the contextual.

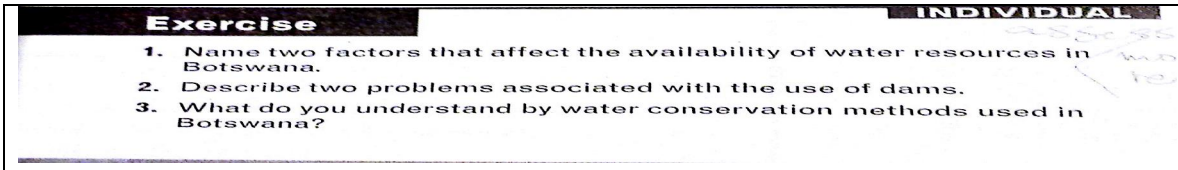
Student prior knowledge

The content in the three textbooks seems appropriate for the students. In their lesson plans, the teachers identified student factors such as students' attitudes that water is plentiful, students coming from different cultural backgrounds and different learning abilities, knowledge of the importance of water, different beliefs and geographical backgrounds. The textbooks do not aptly demonstrate how the new material to be learnt relates to what the student has already learnt in the past, except Ford et al (2009) who make reference to what students learnt previously and how the current content builds on what they have already learnt.

The conceptual teaching strategies

In Gatsha & Ngongola (2009), there are more teaching strategies provided than in other textbooks (see table 6.6), for example: group work, research, presentation, report writing. In

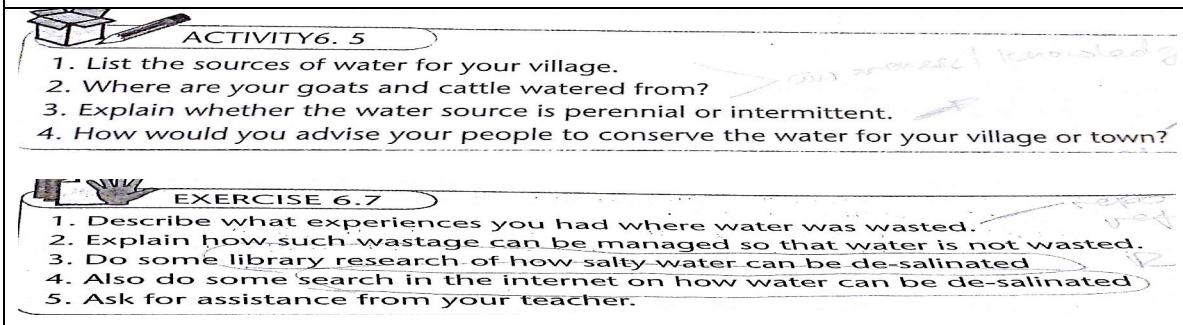
Mpitse et al (2009), there is mention of library and internet research on desalination while most of the activities are exercises for students to do. There is no instruction that these should be done individually or in groups. Ford et al. (2009) does not provide any teaching strategies but provides an individual exercise for the students (see fig 6.6). This exercise is mostly recall.



Exercise INDIVIDUAL

1. Name two factors that affect the availability of water resources in Botswana.
2. Describe two problems associated with the use of dams.
3. What do you understand by water conservation methods used in Botswana?

Ford et al (2009), p. 101)



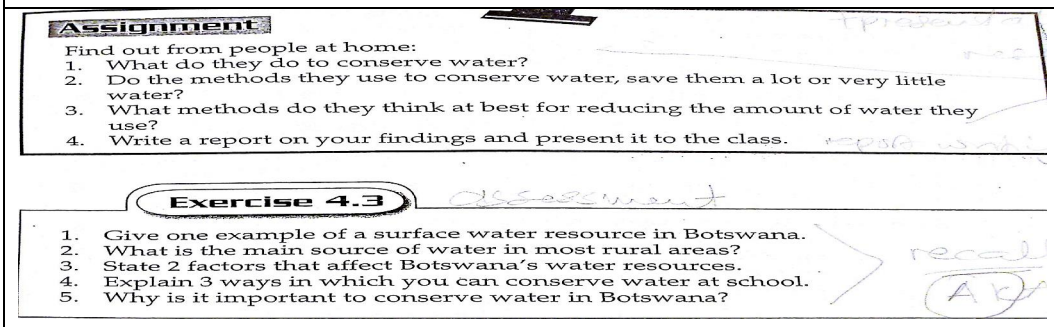
ACTIVITY6. 5

1. List the sources of water for your village.
2. Where are your goats and cattle watered from?
3. Explain whether the water source is perennial or intermittent.
4. How would you advise your people to conserve the water for your village or town?

EXERCISE 6.7

1. Describe what experiences you had where water was wasted.
2. Explain how such wastage can be managed so that water is not wasted.
3. Do some library research of how salty water can be de-salinated
4. Also do some search in the internet on how water can be de-salinated
5. Ask for assistance from your teacher.

Mpitse et al (2009), p. 95 – 100)



Assignment

Find out from people at home:

1. What do they do to conserve water?
2. Do the methods they use to conserve water, save them a lot or very little water?
3. What methods do they think at best for reducing the amount of water they use?
4. Write a report on your findings and present it to the class.

Exercise 4.3

1. Give one example of a surface water resource in Botswana.
2. What is the main source of water in most rural areas?
3. State 2 factors that affect Botswana's water resources.
4. Explain 3 ways in which you can conserve water at school.
5. Why is it important to conserve water in Botswana?

Ngongola &Gatsha, (2009, p. 74)

Fig 6.6. Illustration of teaching strategies and student activities in the textbooks (Ford et al, 2009; Mpitse et al, 2009; Ngongola & Gatsha, 2009)

Although the teaching strategies in the two texts are student-centred, they seem to be information finding activities, that is knowledge about the environment, which is not entirely consistent with the aims and objectives of EE (AKASP). The strategies are more related to general pedagogy than conceptual. This is because the students are expected to find

information, which in most cases is available in the textbook, present it or write a report based on what they found. The assessment activities in all the textbooks are mostly recall, the lowest category in the cognitive domain of Bloom's taxonomy. There are no opportunities provided to the student to learn for the environment.

Table 6.6. Summary of teaching strategies as illustrated in the evaluated textbooks

Textbook	**Teaching Strategy**	**EE teaching and learning component emphasised**
Ford, R., Mlambo, A. & Mosetlhi, S. & Ndaba, V., (2009). *Exploring Social Studies, Form 1*, Heinemann	Naming factors affecting the availability of water resources in Botswana	Knowledge ***about*** the environment
	Describe two problems associated with the use of dams	Knowledge ***about*** the environment
	What is the understanding of water conservation methods used in Botswana	Knowledge ***about*** the environment
Gatsha, G. & Ngongola, V., (2009). *Social Studies, A fresh start Book 1*, Diamond Educational Publishers	Research from home – what is done at home to conserve water, deciding on best methods to use *report writing on findings *class presentations	Learning ***in*** the environment
Mpitse, D. L., Rampha, L. & Tsayang, T., (2009). *Social Studies Form 1*, Collegium	Differentiating between intermittent and perennial rivers and giving examples; examples of 'megobe' and their uses by: * listing water sources in the village; specify where their small stock and livestock are watered from; whether source is perennial or intermittent, suggest some advice on how to conserve water for people in their village or town	Knowledge ***about*** the environment
	* describing their experience with water wastage; explaining how this water wastage can be managed; library and internet research on desalination	Learning ***in*** the environment

The results of the textbook analysis also suggest that these extracts from the books, particularly Ford et al (2009) and Mpitse et al (2009), sufficiently support teachers' PCK on the content component, but fail to support other components, such as the pedagogical. This is shown in the

insufficiency of PCK components such as content representations, curricular saliency, students' prior knowledge, what is difficult to teach and the conceptual strategies.

6.6. PCK in the courses offered at the University of Botswana

I briefly explored the EE methodology course for aspects of PCK. The course being evaluated is both theoretical and practical, as it examines the practical application of EE methodology and the infusion of EE into the syllabus. This is done through the use of the environment as an outdoor classroom for projects and activities. The course also prepares students to become EE resource persons (Ketlhoilwe, 2012). This course is offered mostly to Junior Secondary school teachers, upgrading to BEd secondary education from a wide specialisation range that includes subjects such as English, Setswana, Maths, Agriculture, Social Studies, Business studies, Moral education, Design and Technology and Art.

The course aims at assisting students "obtain the critical thinking, problem solving and methodological skills necessary to implement the integration (and infusion) of EE into the Botswana curriculum as well as provide students with the skills to be resourceful in EE in their teaching career" (Ketlhoilwe, 2012, p. 1). EE is not subject-specific and does not relate to any one curriculum. The objectives of the course include: relating the various methods of infusing EE into the curriculum, demonstrating practical skills and methods of teaching EE concepts, and planning meaningful outdoor classroom activities and field trips. The course is therefore entirely focused on the teaching strategies in EE, hence other components of PCK, such as curricular saliency, content representations, what is difficult to teach and student prior knowledge may not be easily identifiable as they are not priority. The following table 6.7 briefly outlines the activities entailed in the EE methodology course:

Table 6.7. Brief outline of the activities entailed in the EE methodology course

Infusion of EE into the syllabus	- Learning and teaching orientations - Different modes of implementation - Curriculum audit for EE infusion - Infusion methods - Teaching and learning strategies - Teaching for values, attitudes and ethics

The outdoor classroom and field trips	- Objectives of outdoor teaching - Planning and conducting meaningful field trips - Outdoor lessons and activities - Methods of evaluating outdoor lessons and activities

The course activities include syllabus audit for infusion of EE, group lesson planning and class presentations, guest speakers, field trips/work, small and large group activities and discussions outside class. Table 6.7 clearly indicates that the course mainly focuses on the ways in which EE can be infused or integrated into the different syllabi for the various subjects, and also how the teacher can plan for outdoor classroom activities and field trips. The focus is therefore on teaching strategies but not embedded in content. Although components of PCK, like curricular saliency, may be incorporated in the course activities such as the syllabus audit and the lesson plans, the activity is not purposefully intended to address the component entirely.

6.7. Discussion

The data showed that there are some PCK components that are identifiable in the CoRes, the lesson plans and the textbooks, as well as those that are not easy to portray or be captured. The CoRes for the different participants displayed little PCK as shown in the curricular saliency, content representations and teaching strategies. The only aspect of PCK that seem to be developed for most participants in the CoRes is the student prior knowledge. Irene and Naledi seem to have a more developed PCK than the rest of the participants. Curricular saliency and students' prior knowledge were more conspicuous in both the lesson plans and the textbooks while content representations, what is difficult to teach and the teaching strategies were not explicit.

Curricular saliency

To demonstrate a developed curricular saliency, the participants needed to identify correct subordinate ideas and explain links to Big Ideas, show some understanding of sequencing of the concepts, identify possible sources of conceptual confusion, provide reasons for importance of the topic, including conceptual scaffolding, as well as the sequential development of

understanding for specified subsequent topics on the subject. All the participants were able to provide subordinate ideas and content for the Big Ideas except for Boitshepo and Felicia who had no content to be allocated to Big Idea C. Irene, Kagiso and Naledi had content for Big Idea C although it was not well developed or probed. Only Irene seemed to have more profound content for Big Idea C. She was able to place most of her content under the appropriate Big Idea, hence I did not do much reallocation for her (see initial/original CoRes in Appendix E, F and G). For example, the sub-concept water sources, was placed Big Idea A but all the other respondents except Irene placed it under Big Idea B.

The reasons provided for students needing to learn about water resources and management included: gaining knowledge and understanding; appreciation, developing skills and changing their attitudes towards participation in protecting the water resources through conservation and using them sustainably. Although all the respondents acknowledge knowledge and understanding (the cognitive aspect of learning) as one of their reasons for teaching the topic, Kagiso advanced knowledge and understanding more than the others in his Big Ideas. All the participants seemed to espouse attitudinal and behavioural change, which are affective elements. Boitshepo, Irene, Kagiso and Naledi also mentioned the action aspect of participation which comes about as a result of the change in attitudes and behaviour towards water resources. This demonstrates that the teachers are aware of the aims of EE and the importance of using these aims in teaching so as to achieve sustainability. The aspect of skills acquisition seems to be the one that the respondents overlooked as important in giving their reasons for learning about water resources and management.

It is important to note that, according to the rubric, the reasons provided by the respondents for importance of the topic in the Big Ideas were mostly random, and at times not specific to the Big Ideas provided, hence they did not include reference to conceptual scaffolding or sequential development of understanding of other topics in the subject. None of their reasons was about future learning, consolidating past learning or indicating that one idea was close or related to the other. Irene makes an attempt to identify appropriate content for each big idea

and thereafter link the reasons for teaching the Big Ideas with the intended content she provided in a coherent way (see Irene's CoRe, Appendix X).

In the lesson plans, the participants were able to identify the key ideas and the subtopics to be taught during the lessons, as well as show the topics that came before the one to be taught and those that would follow. The respondents were however not able to explicitly articulate the purpose of the lesson. There was a lack of coherence in lesson plans, which could indicate that there is a possible problem of conceptual knowledge on the topic. The data indicated that there were some lesson plans that were more elaborate and consistent than others, especially one by Naledi. This suggests that Naledi's PCK is more developed than that of her colleagues.

Similarly, the three textbooks were to a certain extent able to show understanding of the importance and place of the topic in the curriculum. This is demonstrated in the identification of the main ideas and their subtopics, and also in the depth of the content covered, especially in Mpitse et al (2009) and Ford et al (2009) which outweigh that of Gatsha and Ngongola (2009). I noted that the key questions and the skills provided by the respondents in the focus group correlate with what is in the textbooks. This could be an indication that the teachers rely on the textbooks for information just like the students

Content representation

There was an indication the respondents understood the Big Ideas although there were some Big Ideas that were more understood than others, where the participants demonstrated a greater level of content knowledge. Despite their ability to come up with the content for the Big Ideas, the respondents were not able to adequately provide explanations or examples of specific links to the concepts represented or to students' prior knowledge and experience. There were few instances where they provided examples related to the content, with the exception of Naledi who was able to give explanatory notes and examples that link the representation to the aspects of the concept being explained for the majority of the content in Big Ideas A, B and D (see Appendix X, Big Idea D). Although the respondents showed the intention to use

illustrations like posters, charts, videos and work cards, they did not successfully link these to students' prior knowledge and experience.

The lesson plans showed insufficient allocation of content for the topic to be taught, and minimal examples provided in the form of resources that could be used to enhance the representation of content, such as illustrations, maps, diagrams and pictures. There is mention of posters and charts but these are not clearly defined. The teachers could possibly have used the textbooks for illustration as they include maps, charts and pictures. Visual representations make it possible for students who do not have access to these resources to have a mental picture of what is being discussed and therefore aid understanding. The teachers still need to ensure that the learning of environmental topics also includes actual experience in the environment to give the students hands-on interaction. Literature on the learning of EE has advocated learning through or in the environment as a way of enhancing student understanding of concepts about the environment (Lotz-Sisitka, 2006; Pratchett, 2009; Fien, 1993), like water resources and conservation. Only one respondent, Irene, refers to the textbooks as a resource for learning but she only uses them for assessment purposes.

What is difficult and what is easy

The identified factors that influence the teaching of the Big Ideas, those that make an idea difficult or easy to teach included knowledge of content, behavioural changes, logistical factors (resources, time-table constraints), attitudes and students' diversity and contexts. Students' context and diversity issues, such as traditional and religious beliefs (Irene & Naledi) as well as rural versus urban (Boitshepo & Kagiso) could influence the thinking and learning of students on water resources and their management. Difficulties, identified by Irene on Big Idea A, move beyond logistical constraints. Similarly, Naledi identified some challenges that seemed more conceptual, such as "lack of knowledge of some concept" by the teacher, which could make the learning of the topic difficult. It therefore seems that only Irene and Naledi were aware of the conceptual difficulties that may make the topic difficult to teach, while Felicia and Naledi identified the logistical challenges and Kagiso the contextual challenges.

Teachers were able to identify student factors to consider in teaching the topic but could not demonstrate how they would accommodate these in their lesson plans. These included students' attitudes that water is plentiful (Boitshepo), students' different cultural backgrounds, different learning abilities, different beliefs and varying geographical backgrounds (Naledi). The teachers are able to grasp some of the factors that can influence the learning of the topic. However, there is no clear explanation of the effect of these factors. In their textbook, Ford et al (2009) make an effort to show what the students already know as they start the topic, and how the topic progresses from the known to the unknown. Knowledge of common students' misconceptions and alternative conceptions about the topic is supposed to give insight into how to approach it, and develop teaching strategies that cater for this student prior knowledge. There is no indication in the lesson plan or textbooks how one should address common students' misconceptions and alternative conceptions about water resources and management to enhance student understanding.

Students' prior knowledge including misconceptions

The respondents had an idea of what their students knew and their possible areas of confusion or misunderstanding. In some CoRes (Felicia, Irene & Kagiso), it is indicated that students mix up quantity and quality issues, and also see water as infinite. Irene was able to go into more depth than other respondents as she demonstrated awareness of students' needs and was considerate of their context and diversity, and this was exemplified in her knowledge of the impact of the different traditional and religious beliefs of the students that may influence their thinking in learning about the particular Big Ideas. Naledi was also able to identify traditional beliefs as possibly influencing the learning of the Big Ideas. This showed that the respondents have developed knowledge of their students' beliefs. It is important for the teacher to have insight on their students' thinking because then they can allow students to establish equilibrium between previous knowledge and the new experience or the 'big idea' (Gess-Newsome & Lederman, 1999). It is not clearly evident from the CoRe if the teaching strategies chosen by the respondents catered for their students' misconceptions.

Teaching strategies

A variety of teaching strategies, such as research/investigation projects, reading, discussions, presentations and individual work are provided for the Big Ideas by the respondents. The dominant methods in the CoRes are lectures, group work and discussion. Few teachers mention reading and analysing of text (e.g. Felicia) as a preferred teaching strategy. In the teaching strategies, the respondents just mentioned generalised teaching methods that they used, except in few instances where Irene, Kagiso and Naledi specified teaching strategies like mini-research, reflection papers, site visits and investigations for some Big Ideas. For example, for Big Idea C, Kagiso plans to use site visits to a water pumping station and areas of severe water wastage, as well as engage students in a research project where they identify a problem on water issues and investigate it. Similarly, Irene plans to use research for Big Ideas A and D, show a video on water transportation and invite a guest from the water department to present to the students. Felicia and Irene also include reading as one of the strategies they would employ to engage their students.

The responses on the teaching procedures and particular reasons for using these to engage the students showed minimal evidence of transformation of the content in the CoRes. The main teaching procedures that were considered in this prompt were class/group discussions, debates, lectures and site visits. Although these teaching strategies seem to be student-centred, they are mostly generic, and it is not clear how the choice of the teaching strategy is informed by the content or the learning needs of students. There is also no indication that these teaching procedures take into consideration the student's prior knowledge, which should be used to develop the lesson. Although in their beliefs about effective teaching of EE, some of the participants, like Kagiso and Naledi, had emphasised participation as promoting EE, this was classroom participation, not in the environment for its betterment.

Similarly in the lesson plans, the teaching strategies provided by the participants consisted mostly of group work and discussions followed by presentations, hence promoting learning *about* the environment. There are very few or limited opportunities provided for students to

learn ***in*** the environment while learning ***for*** the environment is missing completely. Although there was an initial mention of a research project when discussing teaching methods to be employed, it disappears in the lesson steps, hence making the strategies seem more generic. Similarly, in the textbooks there is mention of teaching strategies, such as library and internet research (Mpitse et al, 2009) and group work, research, presentation and report writing (Gatsha & Ngongola, 2009), but the way these teaching strategies are used does not seem consistent with the aims and objectives of EE. The strategies are more generic than conceptual. Although group work is student-centred, it may not always be necessarily effective. There is also limited evidence of consideration for students' prior knowledge and possible areas of misunderstanding.

Palmer (1996) has argued that EE should encompass education about, for and in or from the environment and identifies three components: experience, concern and action. The assertion is that "Without these components, no environmental learning can be truly meaningful and worthwhile" (Palmer 1996, p. 145). The identified strategies may therefore not adequately fulfil the three components of experience, concern and action, or, indeed, the goals of EE which entail awareness, knowledge, attitudinal change, acquisition of skills and participation in the sustainable use of the resources in the environment (AKASP).

Some of the content that was taught in the EE methodology course at the University of Botswana included the definition of EE, goals of EE, theories and teaching strategies in EE. In the respondents' lesson plans, there was limited evidence of uptake from the course, particularly in the purpose of the lesson plans. The skills, attitudes and values provided by the respondents' purpose blend well with the goals of EE (see Table 7.4). Although the respondents were able to express the skills and attitudes in relation to the goals of EE, their lesson steps fall short of fulfilling their intentions, and there seems to be a gap between the intended outcomes of the lesson and the enactment. Shulman (2004, p. 234) asserts that the teachers need to "grasp, probe and understand the idea, see its many sides, shape and tailor it until it can be understood by the student." Comprehension on its own is "… not sufficient, the usefulness of knowledge lies in its value for judgement and action." The teachers therefore need to have a

more profound understanding that allows them to come up with sound teaching strategies, or PCK.

6.8. Summary

This chapter investigated PCK in the teachers' CoRes, lesson plans, the main Social Studies textbooks, as well as in the EE methodology course offered to the participants at the University of Botswana. The CoRes revealed that some of the PCK components were more developed than others, like the understanding of the students' prior knowledge and the possible misconceptions that the students may have. The least developed areas were mainly the content representations, as well as identifying what makes the idea difficult or easy to teach. The teaching strategies were mostly too general and not specific to EE, hence suggesting that teachers have little PCK and knowledge on how to enact. When taking into consideration that these lesson plans were developed after the development of the CoRes, they displayed a rather insufficient PCK for the respondents, especially the content representations, what makes the topic difficult to teach, and the conceptual teaching strategies. Similarly, the textbooks lacked aspects of PCK, such as the topic-specific teaching strategies. Although the teachers were provided with an EE methodology course at the University, their lesson steps do not demonstrate much transfer from the course, and there is insufficient consideration for the EE goals of AKASP.

The next chapter concludes the study by considering the findings of the study in relation to the research questions. It reflects on the methodology and the implications of the findings for teaching in general and for the teaching of EE in the Junior Secondary schools in Botswana.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.0. Introduction

The chapter concludes my study by drawing together discussions from the preceding chapters. Firstly, it considers the contribution of the empirical findings to new knowledge in the teaching of EE. I then revisit the research questions and respond to them in light of the main findings of the study. These are positioned by considering the extent to which they relate to PCK in EE. The findings of the study also highlight possible modification of the framework for its potential use in future research. The chapter then reflects on the methodology by considering its strengths and weaknesses; acknowledges the limitations of the study and highlights areas for future investigation. The chapter takes into consideration the implications of the findings for teaching in general, and for the teaching of topics on the environment in Botswana Junior Secondary schools.

The main question that guided my research was 'To what extent are Botswana Social Studies Teachers able to display Topic Specific Pedagogical Content Knowledge on Water Resources and their Management and what factors influence their approaches to the teaching of this topic? ' To help answer the main question, I broke it down it into four sub-questions:

1. What are teachers' orientations and beliefs about good teaching practices of Environmental Education?
2. What are Botswana Social Studies teachers' understandings of the content knowledge associated with the topic Water Resources and their Management?
3. How do Social Studies teachers represent their topic-specific PCK related to the teaching of Water Resources and their management?
4. What other available resources might potentially enable teachers to construct PCK?

7.1. PCK as a construct in Environmental Education

To discuss the findings of the study, I refer to the theoretical framework that I adapted and described in Chapter 2, Section 2.3.1 (Figure 2.3, p. 58) (reproduced as Figure 7.1). The study sought to explore 'the extent to which Botswana Social Studies Teachers are able to display Topic Specific Pedagogical Content Knowledge on Water Resources and their Management and what factors influence their approaches to the teaching of this topic'. There are few empirical studies that explore how PCK relates to both teacher beliefs and content knowledge, especially in EE. The study investigates teachers' beliefs about the environment and beliefs about effective teaching of EE, teachers' understanding of the topic Water Resources and their Management in Botswana, and examines how they transform content knowledge on Water Resources and their Management in Botswana into teachable content. My study therefore offers an understanding on the teachers' representation of their PCK on Water Resources and their Management in Botswana, an EE-oriented topic.

The framework used in the study is an adaptation of Gess–Newsome's (2015) model of teacher professional development and skill, including PCK. It encompasses the main components of my study and my research questions which focus on teacher beliefs about teaching, Content Knowledge and Topic Specific Pedagogical Content Knowledge for the Water Resources and their Management in the Botswana context. This study is based on the assumption that teacher knowledge bases are informed by teachers' knowledge and beliefs and are useful in understanding the capacity of teachers to teach effectively (Shulman, 1986; Darling-Hammond & Baratz-Snowden, 2005). Literature has also showed that beliefs and teacher professional knowledge bases are important in the construction of PCK, hence I considered them in constructing my theoretical framework. I include beliefs in my framework because of the nature of EE and teacher understanding of EE. Teacher environmental beliefs provide evidence of the way they view environmental education (Robertson & Krugly-Smolska, 1997) and impact on how teachers implement EE in the schools. Their beliefs influence the way they teach about the environment.

The theoretical framework for the study is consistent with the national goals for EE in Botswana, namely awareness, knowledge, attitudes, skills and participation (AKASP) and the elements for teaching and learning in Environmental education, namely *about, in* and *for* the environment. AKASP is embedded in the components of concern, experience and action which contribute to individual holistic development in EE (Palmer, 1998). The framework is constructed with the assumption that Teacher Professional Knowledge Bases inform and are informed by Topic Specific Pedagogical Content Knowledge, hence the two-way arrows between the two to show the interrelationship. The framework assumes that teacher beliefs about the environment and about teaching influence their understanding about teaching, especially the teaching of EE topics. Hence I consider these beliefs underpinning factors influencing the TSPCK and vice versa (Magnusson et al. 1999; Davidowitz & Rollnick, 2011). These beliefs also act as amplifiers and filters to teacher learning and mediate teacher actions, so the relationship is shown by the use of two-way arrows between the teacher beliefs and classroom practice. PCK is included under classroom practice since that is where it can be observed.

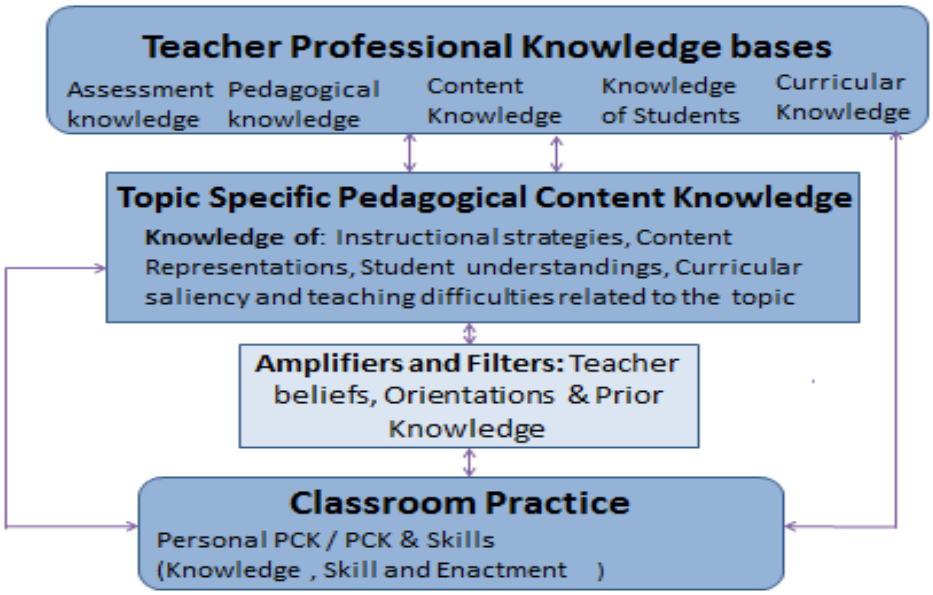


Fig. 7.1. Adapted framework for PCK as used in the study (Gess-Newsome, 2015)

The illustrative adapted framework for PCK as shown in Fig. 7.1 includes Teacher professional knowledge bases, Topic Specific Pedagogical Content knowledge, teacher beliefs and orientations and classroom practice. These are characterised in more detail in chapter two (section 2.3. p. 58). TPKB is knowledge required for practice; it is generic and applicable across all teaching disciplines (Gess-Newsome, 2015). Thus this knowledge is not necessarily specific to Social Studies and EE but relevant across all subject areas. In the study, research question 3 explored teachers' understanding of Water Resources and their Management in Botswana and how they transformed this knowledge into teachable content, hence the inclusion of TSPCK. TSPCK is topic-specific, therefore in my study it was applicable particularly to the topic Water Resources Management, and included knowledge of content, instructional strategies, content representations, student understandings and curricular saliency. Teacher beliefs can influence the way they perceive knowledge and teaching, as well as the way they may enact their classroom practice (Luft & Roehrig, 2007).

The teachers' environmental beliefs and orientations will also impact on how they approach a topic such as Water Resources and Management, which is EE-oriented. In the adapted model, I also included classroom practice which is the location of PCK. The latter is personal knowledge that is context-specific and includes the teaching of a particular topic in a particular way for a particular purpose to particular students (Shulman, 1987; Gess-Newsome & Lederman, 1999; Gess-Newsome, 1999/2015). PCK in the study would be enacted / embodied in the application of knowledge to teaching of the topic Water Resources and their Management by the individual teachers. It can be found in the instructional plans and CoRes that the teachers create and in the reasons behind their instructional decisions (Gess-Newsome, 2015). It is the knowledge that teachers use in transforming content knowledge on Water Resources and their Management into forms that are comprehensible to students (Shulman, 1987). In the section below, I describe the framework in relation to the findings of the study.

7.2. Theoretical findings that contribute to new knowledge

Although the theorised model for PCK (figure 7.1) suggests that there should be a reciprocal relationship between beliefs, teacher professional knowledge and classroom practice, and the knowledge domains of TPKB and TSPCK should work together for effective teaching, the findings of my study suggest that this relationship is not fully developed. It showed that some parts are present while others are missing, and also that the interrelationships between the knowledge domains are weak. Each is working as an isolated body of knowledge. Therefore, not all parts of the model for PCK in the context of EE are working, as they could. The teachers had pertinent beliefs about the environment, about teaching and about EE. They also had the content knowledge on Water Resources and their Management as displayed in Chapter 5. The possibility is that they did not well understand EE concepts, hence their pedagogy was weak.

My review of the literature has contended that the behaviour and practice of teachers in EE are substantially influenced by their thinking and understanding as well as their beliefs (Pajares, 1992; Nickel, 2007). This means that the implementation of EE depends significantly on their thinking, rich knowledge of the content and commitment to environmental wellbeing. Teachers should be able to develop suitable teaching strategies for the environmental topics as well as for the students.

The analysis of the data showed that the teachers had pertinent beliefs about teaching; they claimed some commitment to environmental wellbeing, knew their students and the context in which they teach, and had some developing content knowledge on the EE topic to be taught; however, these did not necessarily translate into the PCK needed for conceptually rich teaching. In Chapter 5, the teachers' acknowledged the importance of having an understanding of the environmental issues, passion, commitment, and promotion of the EE goals (AKASP), and especially participation in their instruction for effective EE. The teachers' representations of PCK via the CoRes or through their lesson planning did not reflect the ideals they professed to have. Their lesson plans did not reflect their professed beliefs. This finding suggests that the teachers may still be faced with the challenge of developing a subtle understanding of EE

concepts for effective teaching and learning of EE, since they may not sufficiently possess all components required for developing their PCK; if they have the components, they are not using them in a relational manner. Thus the findings show that the Topic Specific Pedagogical Content Knowledge and teaching on the topic Water Resources and their Management in Botswana is less than ideal. Figure 7.2 illustrates how the findings of my study might be reflected in a topic-specific representation of PCK for Water Resources and their management. The figure shows what links and kinds of teacher knowledge were demonstrated by the participants in this study. Unlike the proposed theoretical framework in Figure 7.1 where I use relational arrows, figure 7.2 uses lines instead of arrows to show that there is a relationship between the components linked together (Teacher Professional Knowledge Bases, Topic Specific Pedagogical Content Knowledge, Beliefs and Orientations and Classroom Practice); however, the findings do not convincingly show this. I adapt the terms basic, limited, developing and exemplary (Park et al., 2011) as used in chapter 6 of the study to represent the ratings of the different characteristics under each component.

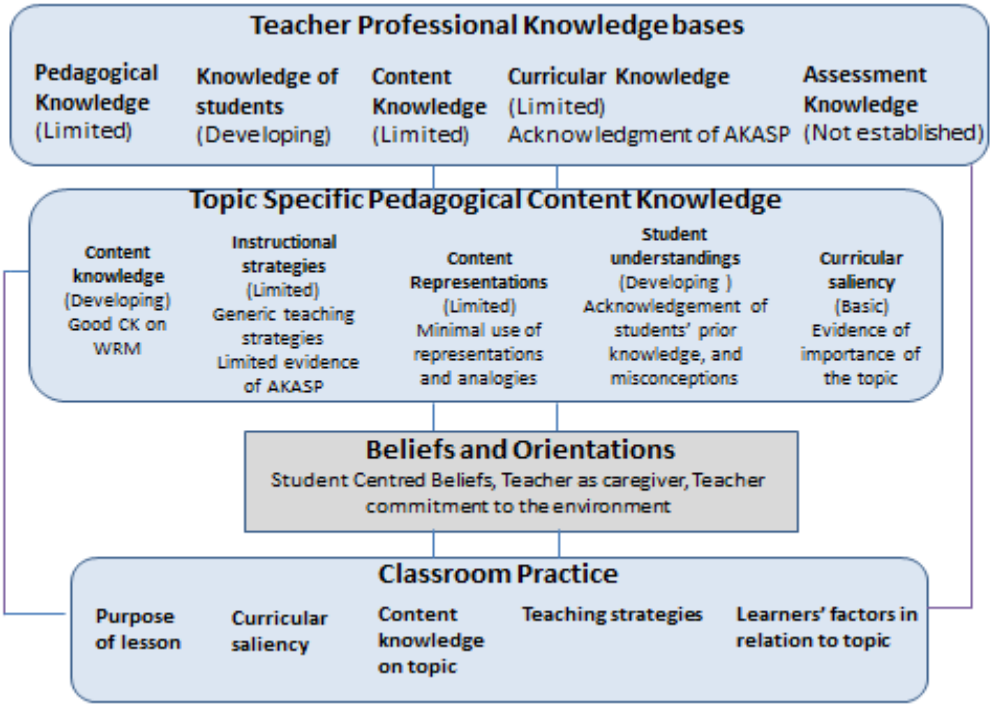


Fig. 7.2. Theoretical framework after findings

In the next sections, I use the model to show what the findings reveal as well as show how the interrelationships work together. I also show how the findings of the study build on the adapted theoretical framework in chapter two and highlight further developments on the model as per the findings.

7.2.1. Teachers' underlying beliefs

The findings of the study noted that the teachers, in their conception of teaching, focus mainly on the interpersonal qualities of the teacher and the emotional needs of the child. The teachers generally perceived teaching as a caregiving profession and they showed limited conception of representation for knowledge and mediating learning. Their beliefs lacked regard for teaching as representation for knowledge. In many cases, their beliefs about teaching underemphasised the importance of content knowledge. Their general focus on being a caregiver to children, while important, may serve to limit their development of PCK. This somewhat undermines the nature of teaching as a knowledge-based profession which extends beyond being nurturing, supportive, patient and kind (Morrow, 2007; Petersen & Osman, 2010) and is central to enabling learning. The implication is that the teachers have a limited conception of teaching, hence they do not have the order and principles from which they can better prioritise the requirements of teaching and learning in the complexities of the classroom. They need "an informed conception of teaching that will help them navigate the multiple and often contradictory demands placed on them" (Rusznyak & Walton, 2014, p. 15). The teachers need to understand that teaching is mediating knowledge by organising systematic learning. Furthermore, their pedagogic decisions are not general, but are crucially linked to the content they teach. This is even more important in teaching of EE where a personal commitment to a sustainable lifestyle is an intended outcome of the learning.

The findings of the study also showed teacher beliefs that considered promoting student learning practices. The teachers acknowledge the need to involve the students in the learning process, thus their articulated (but not necessarily enacted) preference for more student-centred over teacher-centred approaches to teaching and learning. Although these beliefs

agree with learning theories that advocate student-centred approaches like constructivism (e.g. Luft, 2009; Cakir, 2008; Ballantyne & Packer, 1996) and EE pedagogies such as inquiry-based learning and problem-based learning (Barry, 2006; Walker, 1997), the problem is that knowledge-centred (conceptually strong) teaching and learning is not guaranteed. A similar finding was that, although teacher beliefs that consider promoting student learning practices are understood to be associated with the presence of PCK, possession of student-centred beliefs does not necessarily indicate the presence of PCK (Mavhunga, 2012). The findings of the study showed that, despite their consideration for student-centred beliefs, there was no evidence in the CoRes and the lesson plans to relate to their belief, showing a mismatch between beliefs and intended practice. Similarly, Gooch et al (2008) found that teachers' plans often lacked consistency between the teacher's beliefs, intended outcomes, learning experiences and assessment tasks. This inconsistency may jeopardize effective teaching of EE since personal convictions, such as beliefs, influence both the teachers' knowledge and PCK (Davidowitz & Rollnick, 2011; Luft & Roehrig, 2007; Pajares, 1992). The teachers do not see themselves as environmental activists and so knowledge ***for*** the environment is not a priority.

7.2.2. Teacher Professional knowledge bases

Knowledge and beliefs are related in that beliefs influence the knowledge one assimilates or rejects. The findings of the study showed that although the participants perceived teaching as caregiving, they also had some germane beliefs about teaching. The teachers had knowledge of what the students knew, their possible areas of confusion or misunderstanding, and content knowledge on water resources management. Although some of the teachers' beliefs, like the student-centred beliefs, reverberated in the CoRes and lesson plans, there was an indication of how these could be pulled together to enable effective transformation of knowledge and organisation of quality learning experiences for students. The participants provided generic teaching strategies that did not reflect the preferred pedagogies associated with EE, leading to inquiry and action research involving real problems faced by the community in which they stay.

As a scarce resource in Botswana, the management of water in homes and communities could have potentially provided much scope for making this topic a lived experience. The data suggested that teachers' beliefs and their content and pedagogic knowledge were not brought into relation with one another, as they did not necessarily demonstrate a translation into the modelled PCK. Thus each of the knowledge components appeared to be working in isolation rather than together. In the framework, knowledge from the Teacher Professional Knowledge Bases informs and is informed by Topic Specific Pedagogical Content Knowledge, hence the two-way arrows between them (see fig 7.1). This suggests that growth in one knowledge base has the potential to increase knowledge in the other (Gess-Newsome, 2015). The relationship between Topic Specific Pedagogical Content Knowledge and Teacher Professional Knowledge Bases is not explicit in the findings as there is no clear indication of how they influence each other. Although the relationship remains relevant, it is no longer represented using two-way arrows but with lines instead. Since my study was focused on the topic Water Resources and their Management, some of the aspects of Teacher Professional Knowledge Bases were not easily established. Below I briefly show how the identified knowledge components were represented in the data.

Pedagogical knowledge

Pedagogical knowledge is a component of Teacher Professional Knowledge Bases and entails the teacher's views and understanding about teaching and learning, that is, what "counts as good teaching, the best teaching approaches in a given context, issues, challenges, barriers in teaching informed by knowledge of applicable learning theories" (Shulman, 1986, p. 9). Therefore, pedagogical knowledge influences both Topic Specific Pedagogical Content Knowledge and Pedagogical Content Knowledge. The theoretical framework in fig 8.1 above shows this relationship, using a one-way arrow linking Teacher Professional Knowledge Bases to the classroom and the two-way arrows between Teacher Professional Knowledge Bases and Topic Specific Pedagogical Content Knowledge. Although the relationship continues to be relevant (see fig 7.2), the results of the study showed that this was the weakest of the teacher knowledge base, hence making the model fall short. Literature has indicated that effective

teaching in EE entails learning that includes the three important aspects of EE*: about, in/from* and *for* the environment (Palmer, 1998), which are aimed at fostering experience, concern and action *for* the environment. These are encompassed in the national goals of EE, AKASP.

In chapter five of the study, the participants acknowledged that an understanding of the environmental issues, passion, commitment, promotion of the EE goals, and participation by students during instruction enabled effective teaching of EE. The teachers also professed concern for the environment, as well as commitment to environmental conservation, as key in the effective teaching of EE. They understood the national goals of EE as part of the curriculum and how it has to be taught in relation to the situation in the country. The findings showed that despite their acknowledgement of the ideal requisites for effective teaching in EE, there was no evidence or consideration for these important aspects of EE in both the teachers' CoRes and lesson plans. They appeared to know the ideal but failed to translate the concern into action, hence jeopardizing effective teaching in EE. The teachers were unable to capitalize on the potential that the topic of water management offered for action research: contextually-based learning from problems that exist within the community.

Student understandings

The findings in chapter 5 confirmed that the teachers are aware of their students' beliefs and what the students knew about Water Resources and their Management in Botswana, and also their possible areas of confusion or misunderstanding on the topic. The greatest misunderstanding was the belief that 'water is infinite and renewable'. Literature has shown that students come to a learning task with different conceptions, so they may learn different things from the same event and apply their understanding in different ways (Ballantyne & Packer, 1996). It is therefore important for the teacher to have insight into their students' thinking, because then they can allow students to establish equilibrium between previous knowledge and the new experience or the 'big idea' (Gess-Newsome & Lederman, 1999; Ballantyne & Packer, 1996). The framework therefore remains with the arrow that links students' knowledge and PCK to show the continued relationship between the two (see fig. 8.1

above). Despite the teachers' awareness of their students, and the belief in student-centred teaching strategies, the suggested teaching strategies by the participants, especially in the focus group, were not indicative of how students' prior knowledge could be used to develop the lesson.

Content knowledge on Water Resources and their Management

A good knowledge of content precedes the ability to develop suitable instructional strategies (Darling-Hammond & Baratz-Snowden, 2005; Shulman, 1986; Bransford et al, 2000) and allows the teacher to present content in a multitude of ways that are understandable to the students (Grossman, 2005; Rusznyak, 2009). Thus, conceptual clarity provides conditions for thinking about pedagogical transformation. Content knowledge in my study is incorporated under TPKB, TSPCK and as teacher prior knowledge under teacher amplifiers and filters. The findings also noted conceptual confusion between quality and quantity management issues. This could suggest that the teachers could still be grappling with the topic since they had only been teaching the topic for a period of two years. Limited CK may pose a challenge in enabling teachers to derive the big ideas for a topic and failure to present content in a variety of ways that make it more accessible to the students. If the teachers have some misconceptions and confusions, these may be transferred to the students. This would have implications in the effective teaching of Water Resources and their Management in Botswana, as the teachers find themselves having to teach a topic they are not very conversant with, and consequently compromising effective teaching.

The findings showed that teachers possess sufficient understanding on water resources and management, e.g. the knowledge of the water issues in the country, why it is important for the students to learn about water management and conservation. While the teachers displayed a developing understanding of CK, the findings indicated that CK was stronger on some big ideas about Water Resources and their Management in Botswana than others. For example, CK was stronger for the big ideas A (Many human activities depend on access to water), B (Although water is a renewable resource, the amount of usable water available is limited by how much

can be stored) and D (Water pollution can decrease its usability), while for big idea C (Water can be transported from one region to another), it was weaker. There was also no evidence of opportunities for application of this knowledge into real day-to-day experiences or practices in students' everyday lives.

Knowledge of instructional strategies

If it is to develop knowledge, understanding and a commitment to sustainable living, EE methods should promote learning which is student-oriented and inquiry-based; hence the need for teachers to have in-depth knowledge of the subject matter, the content (Tal & Argaman, 2005) and a developed PCK. The findings from the lesson plans and the CoRes showed minimal evidence of transformation of the content and teachers mostly producing non-specific teaching strategies for teaching an EE-oriented topic. The teachers, for the greater part, emphasised learning about and in the environment, whereas learning for the environment was undermined. This scenario could suggest that although the teachers are aware of the obligations of the national goals of AKASP, they still lack the ability to develop conceptual teaching strategies specific and suitable for EE topics; hence they regard teaching as a generic practice and teach EE generically as they would any other subject. This could have negative implications on effective teaching in the classrooms, since teaching has been argued to extend beyond being nurturing, supportive, patient and kind (Petersen & Osman, 2010) but central to enabling learning (Morrow, 2007). The topic Water Resources and their Management requires instructional activities which provide students with real life learning about water and water resources in their environment. These would include strategies such as learning outside the classroom, inquiry and problem-based learning, which allow students to interact more with their local water issues. This would promote participation and the decision to safeguard water and water sources.

7.2.3. Topic Specific PCK on 'Water Resources and their Management' in the context of Botswana

In the framework for the study, PCK is located within classroom practice (see fig. 7.1). It was displayed in the application of knowledge to the teaching of the topic Water Resources and their Management by the individual teachers. It is the knowledge that teachers use in transforming content knowledge on Water Resources and their Management into forms that are comprehensible to students (Shulman, 1987). Since the scope of the study did not extend to the classroom, I used lesson plans as a window into classroom practice. The limitation of the findings is that the conclusions drawn from the lesson plans only included purposes for teaching, content, students' factors in relation to the topic, learning strategies and the use of materials. There are many other aspects of classroom practice that were not included in the data for the study. I therefore explored the knowledge of, reasoning behind, and planning for teaching the topic Water Resources and their Management in Botswana. I examined the teachers' purposes for their teaching of the topic and the ways the topic was taught to Form 1 Junior Secondary students.

I was particularly interested in exploring how teachers transformed their knowledge on water resources management into teachable content. Transformation of knowledge into suitable teaching and learning experiences is one of the key elements in the establishment of PCK. Transformation occurs as the teachers think through the topic to be taught. They draw on their content knowledge and knowledge about their students. I therefore also included the knowledge components from which transformation emerges (Geddis & Wood, 1999; Mavhunga, 2012) to cater for the analysis of the CoRes and lesson plans which were the main data tools for exploring topic-specific PCK in the study. These include curricular saliency, content representations, what is difficult to teach, students' prior knowledge and conceptual teaching strategies.

The teachers' challenge extends beyond just comprehending a topic and transmitting knowledge to students; they must also transform the content into a "… pedagogically reasoned "plan, or set of strategies, to present a lesson" (Shulman, 1987, p. 104). This process of

transformation requires the teachers to construct PCK by pulling together their subject matter knowledge, pedagogical knowledge, their knowledge of context and their knowledge of their students. The findings showed that some of the components, like students' prior knowledge, were easier for the teachers to articulate than others. The less developed components in the CoRes included curricular saliency, content representations and conceptual teaching strategies. Although the teachers had good knowledge of the students and of the content, they were not able to design lessons to further the goals of EE, nor build on the students' pre-instructional knowledge, which suggests a lack of appropriate pedagogical knowledge and instruction. The findings confirm that teachers are aware of the conceptual difficulties of their students but do not have the ability to respond adequately (Bozkurt & Kaya, 2008; Dickerson et. al., 2007; van Dijk & Kattmann, 2007).

In the sub-sections below, I briefly describe the findings in relation to the knowledge components from which transformation emerges.

Curricular saliency

Despite not being able to come up with the big ideas for water resource management themselves, the findings showed that some participants were better able to allocate content to the provided big ideas than the others. Although the majority of the participants were able to provide subordinate ideas and content for most of the big ideas, the one on water transportation to other regions was least developed.

The reasons provided for why it was important for students to learn about Water Resources and their Management included gaining knowledge and understanding of the environment; appreciation, developing skills and changing their attitudes towards participation in protecting the water resources through conservation; and using the resources sustainably. Even though the identified reasons correspond with the national goals for EE and sustainability, these were not explicitly represented or articulated in either the CoRes or the lesson plans.

The findings also showed that of all the goals of AKASP, the aspect of skills acquisition seemed to be the one that the participants did not advance strongly in their reasons for learning about water resources and management. There was little evidence in teachers' responses on knowledge of what needs to be covered prior to the topic and what not to teach at that particular point. It is knowledge of curricular saliency that enables a good teacher to judge aspects of their teaching, such as depth of treatment and contextualisation. This oversight on skills development, limited knowledge on prior topics and what not to teach may have implications that inhibit opportunities for effective teaching and learning about sustainability of water and its resources.

Representations and analogies

Content representations are indicated in the ability to illustrate or describe a concept in different ways through analogies, demonstrations, diagrams or symbolic representation (Mavhunga, 2011). Although this component was included to illustrate the transformation process, it was not evident in the participants' CoRes and lesson plans, nor in the explored textbooks. There were few instances where examples or illustrations relating to the content were provided. The participants also did not adequately provide examples of specific links to the big ideas or to the topics planned for their lessons. In some instances, the respondents conflated representations with resources. Even though the respondents included these additional materials to enhance learning, these were just generic resources rather than specific ones. The respondents just provided a list of resources without relating them explicitly to the content.

What makes the topic difficult to teach

Most of these challenges identified by the participants on what made the topic difficult to teach were logistical and not conceptual. These included lack of resources, time table constraints and big class sizes. Other factors included knowledge of content, students' attitudes/behaviour/diversity and contexts. In their responses, the participants acknowledged their students' prior knowledge and/or common misconceptions as difficulties. Despite this,

there was minimal demonstration of curricular saliency, i.e. sequencing, what not to discuss yet, emphasis of important conceptual aspects or evidence of some kind of thoughtful selection and effective use of varied strategies appropriate to the content and students. The participants provided inadequate justification for their choice of teaching strategy consistent with EE specific strategies: in, about and for the environment.

Knowledge of their students' prior understanding

The findings also showed that the respondents knew about their students' beliefs since they were able to identify various possible misunderstandings on water resources and management. Despite this ability, the participants were not explicit in the CoRes on how the teaching strategies they chose catered for their students' misunderstandings. Teachers who can identify students' prior knowledge will find that this may be something that makes a topic difficult to teach. It is important that the teacher is aware of the different conceptions the students have about a topic. This enables them to design learning activities that challenge the existing conceptions so students can reconstruct their personal theories (Ballantyne & Packer, 1996; Cakir, 2008; Gess-Newsome & Lederman, 1999) towards meaningful learning.

Topic-Specific teaching strategies

A closer look into the teaching procedures and particular reasons for using these to engage the students showed minimal evidence of transformation of the content in the CoRes. The main teaching procedures provided by the respondents mainly included: class/group discussion, research, debates, lectures and site visits. There was no evidence of topic-specific teaching strategies provided by the participants.

Although these teaching strategies seem to be student-centred, they are mostly generic and it is not clear how the choice of the teaching strategy is informed by the content or the learning needs of students. Alvarado (2010) also established that teachers used multiple approaches, not necessarily all of which are suggested in the curriculum, but realised that there was a mismatch between the approaches they said they would use and what they actually did in the

classroom. The ability for the teacher to develop student-centred teaching strategies that support and encourage students' responsibility for their own learning is reliant on a rich knowledge of the subject matter (Luft & Roehrig, 2007; Park et al, 2011; Mavhunga, 2012). Since the teachers showed fairly good understanding of content knowledge on the topic Water Resources and Management, one expects that their ability to think about its application for teaching (PCK) would be well developed. However, the teachers mostly produced generic teaching strategies that were not necessarily EE-specific. The lack of developed conceptual teaching strategies suggests that the teachers did not "grasp, probe and understand the idea, see its many sides, shape and tailor it until it can be understood by the student" (Shulman, 2004, p. 234).

The fact that the participants' teaching procedures do not take into consideration the students' prior knowledge or use the latter to develop the lesson may suggest "that transmission of facts, content, knowledge, and/or benchmarks/standards is still the most prevalent goal and belief about teaching" and that "…"teaching for the test" remains a strong driver of teachers' overall instruction" (Alvarado, 2010, p.321). The teacher has to ensure that they present opportunities for real-life learning to students, by using education about, for and in or from the environment in their instruction (Walker, 1997; Palmer, 1998). Although in their beliefs about effective teaching of EE, some of the participants, like Kagiso and Naledi, had emphasised participation as promoting EE, this turned out to be classroom participation, not in the environment for its betterment.

7.3. Summary of my findings and how they answered my research questions

The main question that the study sought to explore is the extent to which Botswana Social Studies Teachers are able to display Topic Specific Pedagogical Content Knowledge on Water Resources and their Management, and the factors that influence their approaches to the teaching of this topic. These factors include their environmental worldview, their understanding of Environmental Education teaching and their knowledge of the content. First, I set out to understand the construct of PCK and its dynamics across the literature so that I could establish

the parameters for the theoretical framework of the kind of PCK within which my study lies. This was described in chapter two. To help answer the main question, I subdivided it into four sub-questions for the components of the study to be explored. These would include the beliefs, EE teaching, the CK and the PCK as a result of transformation of the CK on Water Resources and Management. Below is a brief summary of my findings.

7.3.1. Research sub-question 1: *What are teachers' orientations and beliefs about good teaching practices of Environmental Education?*

This question was included for all the teachers taking part in the study, those in the focus group and those who answered the questionnaire but were not part of the focus group. The findings from the general beliefs about teaching showed that there was a lack of regard for teaching as representation for knowledge, and more concentration on its peripheral goals that do not look at making knowledge accessible to students. Although there was acknowledgement of the importance of knowledge as playing a role in teaching, and occasional glimmers of knowledge-based approaches, focus was mainly on the interpersonal qualities of the teacher and the emotional needs of the students. Furthermore, the findings showed that some of the teachers still had a context-bound conception of teaching, and needed to understand that teaching is mediating knowledge by organising systematic learning. There were those teachers who believed that a combination of both pastoral roles and knowledge would make one an effective teacher.

My study was focused on topic-specific knowledge and roles for teaching in EE, which emphasise the development of the "student's awareness, understanding and skills through student-centred methods" (Botswana Government, 1999). Despite the participants' emphasis on commitment to the environment and participation by both the teachers and the students, few responses reflected subject-specific responses, such as experiential learning, storytelling, values education, enquiry learning, future problem solving, learning outside the classroom and community problem solving (UNESCO, 2002; Ballantyne & Packer, 1996; Cakir, 2008; Walker, 1997; Fien & Gough, 1996). There was minimal consideration of student inquiries, organising

dialogue and interaction among students about various ideas, and supporting the development of students' responsibility for their own learning. Inquiry involves identifying a local problem, and rigorously and critically analyzing what is going on, where improvements can be made and seeing if students can effect those recommendations in their home and in their school. Water wastage and polluting are two universal issues that could be used to really promote inquiry. Nevertheless, teachers could not see the potential to do so since the results showed a very generic approach to teaching, in which generic strategies are applied to content, with very little consideration of the nature of the knowledge, or to the roles of EE. The approach is therefore a technological/techno-rationality approach, which is not knowledge-based.

7.3.2. Research sub-question 2: *What are Botswana Social Studies Teachers' understandings of the content knowledge associated with the topic Water Resources and their Management?*

The findings indicated that to a greater extent, all the teachers were informed and knowledgeable on water issues in the country. The Social Studies syllabus objectives require that students be able to "discuss the factors affecting water resources in the country" as well as "assess water conservation practises in Botswana" (Botswana Government, 2008, p. 2). The teachers generally knew many facts on the topic water resources management, but were not able to impose a conceptual order on the topic. When given a conceptual order, they were able to elaborate on each of the big ideas, some of which were more developed than others. There were many different degrees of conceptual accuracy. The data showed that the teachers could not move beyond the given information in the textbooks, to think about the common water wastage/pollution in their own communities and in the everyday lives of children. As a result, learning remains at book knowledge, since there were no opportunities provided for links into what the students saw around them in their own community.

7.3.3. Research sub-question 3: *How do Social Studies teachers represent their topic-specific Pedagogical Content Knowledge related to the teaching of Water Resources and their Management?*

To answer the sub-research question, I used CoRes and lesson plans for the case study group to portray and capture their PCK around the teaching of Water Resources and their Management. I particularly concentrated on the components from which knowledge transformation emerges, as illustrated in Fig. 7.1 under Topic Specific Pedagogical Content Knowledge.

The findings showed that some of the components, like students' prior knowledge, were easier for the teachers to articulate than others. The less developed components in the CoRes included curricular saliency, content representations and conceptual teaching strategies. Although the teachers had developed knowledge of the students and of the content, they were not able to design lessons suitable for their students. Below is a brief summary of the findings as per the PCK components:

** Curricular saliency* - The findings showed that the respondents were not able to identify the big ideas for the topic, but once the big ideas were provided to them, they were able to explore the big ideas, some more than others. Although the data showed consideration of the five goals of EE in Botswana by the teachers (AKASP, as well as the teaching *'about, in* and *for* the environment'), these aspects were not represented in their suggested teaching strategies.

** Content representation* - Content representation was notably one of the least developed aspects of the teachers' PCK.

** What is difficult and what is easy to teach* - The difficulties identified by the participants were mostly logistical constraints rather than being conceptual.

** Students' prior knowledge including misconceptions* **-** The data showed that the respondents were perceptive of their students' possible areas of confusion or misunderstanding, their students' beliefs and how these could probably make the learning of the topic difficult.

* *Teaching strategies* - The participants provided a variety of generic teaching strategies without providing reasons for using these to engage the students. Although these teaching strategies provided seemed to be student-centred, they lacked evidence of transformation of

the content or consideration of students' prior knowledge. They were also not closely connected to the goals of EE for motivating students to adopt sustainable lifestyles. For example, looking at the ways students themselves use, waste and pollute water would allow them to evaluate these and make personal choices to be "Water Wise."

7.3.4. Research sub-question 4: *What other available resources might potentially enable teachers to construct Pedagogical Content Knowledge?*

When I established that the EE-specific PCK was largely absent in teachers' CoRes and lesson plans, I decided to look further for other potential sources of PCK that might support teachers' construction of topic-specific PCK. I investigated textbooks to establish the extent to which they could provide direction for teachers with opportunities to construct PCK. The data shows that there are some PCK components that are identifiable in the textbooks, as well as those that are not easy to portray or be captured. Curricular saliency and students' prior knowledge were more conspicuous, while content representations, what is difficult to teach and the teaching strategies were not explicit. The three analysed textbooks were to a certain extent able to show understanding of the importance and place of the topic in the curriculum. There is limited information in the textbooks about how one should address common students' misconceptions and alternative conceptions about Water Resources and their Management to enhance student understanding. The teaching strategies used in the textbooks also do not seem consistent with the aims and objectives of EE (AKASP). They are more generic than conceptual, with limited tasks where students critically examine their own water usage in their homes, around the school and in their community.

7.4. Identifying a workable theoretical framework

Initially when choosing the theoretical framework, I preferred the Davidowitz & Rollnick (2011) PCK model because it includes PCK, teacher knowledge domains and beliefs, which form an integral component in my study. As the study evolved, it became apparent that this model was inadequate since it did not include the Topic Specific Pedagogical Content Knowledge (TSPCK), whereas my study was focused on the topic Water Resources and their Management in

Botswana. To overcome this, I decided to adapt the Gess-Newsome (2015) model of teacher professional knowledge and skill that includes PCK. This model identifies the overarching role of teacher professional knowledge and situates PCK within that model, including all of the complexity of teaching and learning (Gess–Newsome, 2015). I adapted the model by including the knowledge domains of Teacher Professional Knowledge Bases (TPKB) and Topic Specific Pedagogical Content Knowledge (TSPCK), with teacher beliefs and orientations as amplifiers and filters for TSPCK, and classroom practice where PCK is located. I also incorporated into the framework the components in Environmental education *about, in* and *for* the environment, which are embedded in the components of concern, experience and action (Palmer, 1998). These are in sync with the national goals for EE in Botswana, namely awareness, knowledge, attitudes, skills and participation (AKASP).

The model was adequate in terms of investigating teacher beliefs, teacher knowledge and the components of EE. As the study developed, so did the data collection strategies. The data collection in the study did not include classroom observations; therefore the classroom practice aspect of enactment, PCK & S (the act of teaching) was removed in my adapted model. Instead, the framework adopted Personal PCK which is the "knowledge of, reasoning behind, and planning for teaching a particular topic in a particular way for a particular purpose to particular students for enhanced student outcomes" (Gess–Newsome, 2015, p. 10). This aspect was not explored in totality but as a window into practice instead. Since literature has argued that teaching is transformation of SMK, I therefore included the different knowledge components from which subject matter transformation emerges (Geddis & Wood, 1997; Mavhunga & Rollnick, 2011; Mavhunga, 2012) to explore teachers' PCK on Water Resources and their Management. These knowledge components include students' prior knowledge, curricular saliency, what is difficult to teach, representations and conceptual teaching strategies. These knowledge components are also included under TSPCK and they facilitated the analysis of the CoRes, lesson plans and textbooks that are used by the teachers as teaching and learning resources. In the light of the findings, I then proposed an adapted ideal framework for PCK in EE (see fig 7.3).

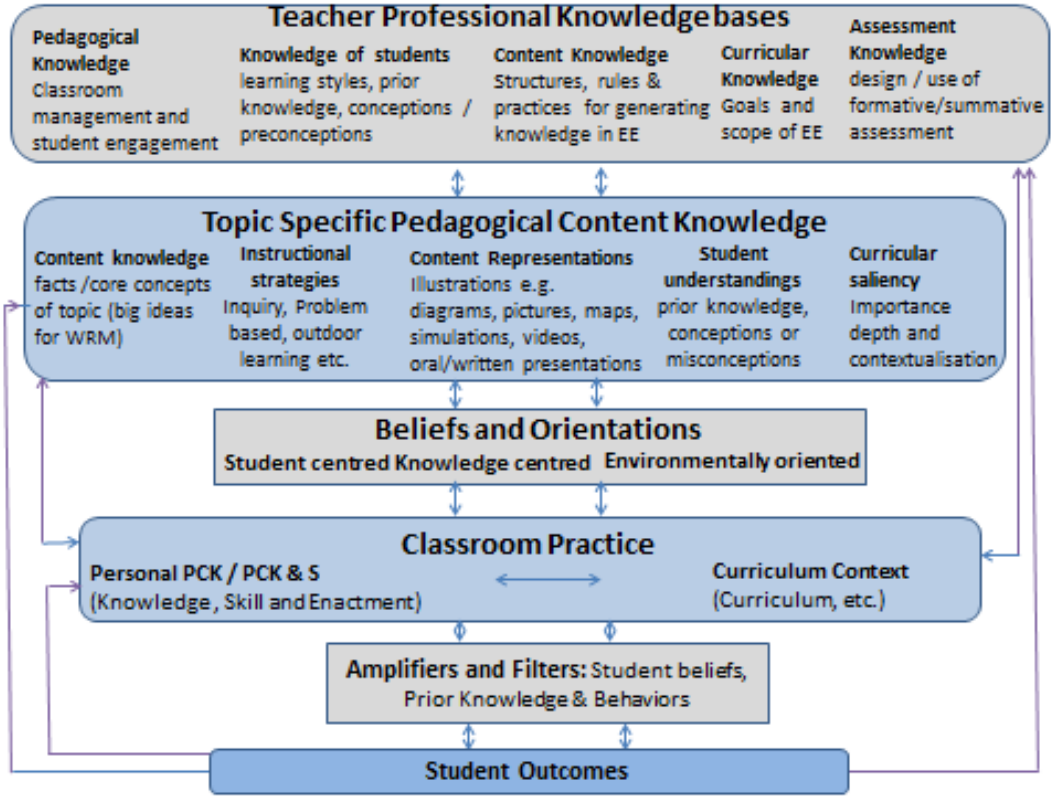


Fig 7.3. Adapted Ideal framework for PCK in the context of EE

This model builds on the adapted model as used in the study (see fig 7.1). It encompasses the categories of Teacher Professional Knowledge Bases (TPKB), Topic Specific Pedagogical Content Knowledge (TSPCK), teacher beliefs and classroom practice, where manifestations of PCK are evident. The adapted model was initially developed for science in general but not for EE, and I modified it to be suitable for EE. EE learning has an important attitudinal dimension which also includes action; hence the model takes into consideration the national goals of EE, as well as the components of teaching and learning of EE as espoused in Palmer (1998). The framework also includes student amplifiers and student outcomes.

7.5. Reflections on the methodology and its limitations

This section reflects on some aspects of the methodology, particularly the strengths and the weaknesses. It points out possible limitations of both the methodology and the study as a whole. The tools chosen for collecting data were developed and modified with the help of the

adapted theoretical framework. These tools included the teacher questionnaire, the beliefs test and the CoRe template. Below is a brief reflection on these tools, their strengths and weaknesses.

7.5.1. Working with the CoRe template

The CoRe is a data collection tool proposed by Loughran et al (2004/6/8) for the enunciation of PCK. In my study, the CoRe template enabled the participants' improvement in understanding of SMK within the topic Water Resources and Management. This was demonstrated in the significant improvement of the teachers' probing of the questions, from the initial mind maps and brainstorm that the participants embarked on prior to the completion of the CoRe.

During a reflection session with the members of the focus group, they stated that the CoRe template was very challenging and was additional work for them, but they also concurred that it was indeed a very useful tool which could help them to be better teachers. This confirms the assertion by Loughran et al (2004) that CoRes do prompt teachers to meaningfully reflect on their practice. The participants' sentiments on the CoRe could suggest that teachers are not used to conceptual planning of lessons, which transforms content knowledge. They are used to planning that is routine, generic and mechanical. Although the teachers do their scheme of work every term and also do lesson plans daily, it would seem that the department of Secondary Education does not explicitly expect or require teachers to consider questions, such as those in the CoRe, in relation to their teaching. The Department of Secondary Education requirements of teachers, in terms of planning and conceptualization of lessons, possibly do not support the development of their PCK.

As noted in chapter six and above, some of the prompts for the CoRe were not adequately addressed. For example, the prompt on the reasons for choosing a particular teaching strategy and the ways of ascertaining students' understanding were not provided. Similarly in his study, Bertram (2010, p. 341) found that that all the participants only listed the teaching procedures but did not provide any particular reason for their choice of the teaching strategies. Furthermore, the participants also did not offer any description of student confusion or "a likely

range of responses" for the prompt on ways of ascertaining students' understanding. This could suggest that the participants may have been overwhelmed by the magnitude of the task as they had never been required to think through these issues before. By the time they approached these final prompts, they were more intent on completing the CoRe than extending their efforts further. It also became apparent from the feedback by the participants that the CoRe was rather challenging for them, which agrees with Bertram's (2012, p. 341) contention that "a degree of familiarity with constructing a CoRe is required and that working with a CoRe requires more time and energy that initially appears necessary".

7.5.2. The Beliefs tool

Although the prompts for the CoRe were initially used for interviews and class observations in the TBI by Luft and Roehrig (2007), when developing my beliefs tool, I also used them as an exercise which the teachers had to complete individually. I adapted only four out of the seven questions in the beliefs tool. The TBI was originally an interview designed to explore pre-service science teachers' beliefs about teaching the subject, but, in this study, I used it as a questionnaire with in-service Social Studies teachers, so I included more questions to enhance my investigation on teachers' beliefs. These questions sought to explore teachers' choice of teaching as a career, what they love about their job and challenges in their job, in order to explore teachers' beliefs on teaching in general. I also introduced the idea of metaphors, where teachers liken their job to any other and explain why they believe teaching is similar to that other job (see appendix B). This allowed for deeper exploration of what the teachers believe about teaching in general and teaching of EE-oriented topics. I also introduced metaphors to further unearth teachers' beliefs about their profession.

7.5.3. The WSOE rationale for lesson design template

I used the WSOE rationale for lesson design template for an individual lesson planning activity by the respondents. This template was designed by WSOE along with guidelines by Rusznyak and Walton (2011) to be used on a teaching experience course for a whole year for pre-service teachers at the University of the Witwatersrand. I realised that the respondents may not have

been familiar with the template but most of the components of the template are aligned to the prompts in the CoRe template, hence the template was not completely foreign to them. Despite this, the effectiveness of the template may have been compromised when used with respondents who were not very familiar with it and were not exposed to it for a period of a year, as is required.

However, the participants in the focus group felt that the WSOE rationale for lesson design template, although challenging, was worthwhile. Irene stated that both the CoRe and the WSOE rationale for lesson design template "allow you to prepare well for your teaching and allow you to be broader in scope and force you to intensely research before you can tackle a concept so that you are at a higher level than the students, which is a requirement for teaching. You find that with our current system of planning, it is more of routine but the CoRe counter routine in that it encourages reflection" (Irene's reflection interview). A lesson planning structure that seeks to develop PCK seems difficult for the participants because, although lesson planning is mandatory for all teachers, according to the Botswana Ministry of Education, the monitoring and demands for planning do not necessarily support the development for knowledge needed for CK, or for the development of PCK. So the lesson planning requirements the teachers are used to seem to be more procedural. The lesson planning structure is the traditional one that seeks for demographic and general information about the lesson and topic to be taught. It is the kind of planning that does not provide an opportunity for teachers to deeply explore the depth and knowledge requirements for the topic, so as to allow for the transformation of content into CK, into teachable knowledge and for effective teaching and learning.

7.5.4. Case study size

My study constituted a total of 26 teachers, five of which were teachers for the focus group in the whole country. This participant size limits the generalisability of the results. Despite the small size of the case study group, Bassey (1999) argues that "the outcome of empirical educational research should include fuzzy predictions. The findings (or results) give an empirical statement of what has been found out about the actual people-events-situation under study.

The prediction is a fuzzy generalisation which extrapolates the findings to similar people-events-situations and suggests that similar findings may be discovered elsewhere." The findings of my study therefore suggest that the Social Studies teachers in Botswana have adequate CK but poorly developed PCK. This has implications on the effective teaching of both EE and the subject as a whole. Despite the small sample size, Bassey (1999) argues that "making a best estimate of trustworthiness demands that the researcher thinks about the empirical findings of a research project in terms of who may use it - and how useful it may be to them." The findings for this study bring the development of teachers' PCK and their professional development as a whole into focus.

7.6. Implications and recommendations

The following section discusses the implications of the study, and also suggests possible areas for further research.

7.6.1. Implications for EE policy implementation

In chapter two, literature has shown that the implementation of EE is still lagging as there is a gap between the intended and the enacted curriculum. The policy and the Social Studies syllabus recommend that students, in their development of environmental consciousness and concern, should be allowed to acquire a global environmental perspective through local and regional environments, and through the use of a variety of educational approaches that encourage appreciation and empathy with the environment (Botswana Government, 1999). Students should take a more active part in the learning process. EE should promote teaching approaches such as inquiry, group work and presentations, as well as class debates over the chalk and talk method of instruction. Despite this recommendation, the findings of my study showed that, due to limited PCK, teachers may still be faced with the challenge of developing a subtle understanding of EE core concepts for an implementation that instigates lifestyle changes. Alvarado (2010) proposed that teachers should always engage in reflection, and give students a chance to think about their prior knowledge and previous experiences. Students should assess what they are learning, for example, how they use (and waste) water in their own

homes. This allows both the teachers and the students to analyse how social and political structures contribute to the occurrence of environmental problems, and consequently to make informed decisions about their actions in the environment. The Research Unit in the Ministry of Education and Skills Development should therefore initiate more research on PCK in general, and PCK in EE in particular, to establish how PCK enhances effective teaching, and put in place structures that will promote the development of PCK among teachers in the country.

Although the policy guidelines and aims on EE seem to promote activism towards prompting changes to sustainable living, the gap between the policy intentions and what actually happens in the schools continues.

7.6.2. Implications for teacher professional development

Teaching deserves professional status (Shulman, 1986, p. 222). Proponents of professional reform believe that there is the existence of a "knowledge base for teaching" which can be used to understand the education and performance of teachers. This knowledge base for teaching is "a codified or codifiable aggregation of knowledge, skill and understanding, and technology, of ethics and disposition, of collective responsibility – as well as a means of representing and communicating it" (Shulman, 1986, p. 222). The journey to professional learning "is often characterised by individual teachers finding themselves questioning their own practice and seeking new ways of constructing teaching and learning experiences without necessarily being supported, encouraged or rewarded for doing so" (Loughran et al., 2006, p. 7). The professional knowledge of teachers further requires some kind of unique and special language that enables teachers to express and share their ideas and experiences regarding teaching and learning.

In chapters four and five, the goals and beliefs about teaching of the five participants appeared to be limited within the content that they had to teach, and not particularly on how the topic, as an environmental topic, had to be taught. Although their goals and beliefs were largely dictated by their obligation to the Social Studies syllabus, they disregarded the EE goals of skills development, as well as action or participation for environmental sustainability. This suggests

that, to maximize participation and skills development in the classroom, elements of action competence (AC) need to be included in the social studies syllabus and the curriculum as a whole (Alvarado, 2010). Teacher education is a "direct reflection of what a state intends for the education of its children, thus how we teach teachers is a reflection of how we want children to be taught and likewise, how we think they learn" (Hunter & Molapo, 2014, p. 296). It is therefore the responsibility of the Department of Teacher Training and Development, as well as tertiary institutions, like universities and teacher training colleges, to strengthen existing teacher education and professional development activities that assist teachers to learn to teach in reform-oriented ways. This would entail teaching that is active, reflective, collaborative, impassioned and communal (Shulman, 1997). These principles can be used to design interventions and construct evaluation tools for teaching. Both the teacher and the students have to be active participants in the teaching and learning process.

The department should design in-service programs that cultivate teachers' thinking in multiple and authentic contexts (Pedretti & Bellomo, 2013), and enable the teachers to talk, share and reflect on their practice and collaborate with peers in ways that scaffold and support each other's learning. Furthermore, teachers in training should have time to practice the skills they were learning about in the college classroom, rather than focusing on content, specifically textbook and didactic lessons, and over-pedagogical content knowledge (Major & Tiro, 2012). Gess – Newsome (2015) recommends that professional development activities developed for teachers should be those "that attend to the specific topics and the specific students, the greater the potential for knowledge and skill use" (p. 40). Traditional and transmissive ways of teaching where the teacher is the one in control and there are little opportunities provided for students' creativity and imagination should be discouraged.

The Department of Teacher Training and Development (TT&D) should therefore create and overhaul opportunities and structures that can allow teachers to form and facilitate communities of practice, and that would allow them to develop professional knowledge about teaching through reflection on "practice and on the experiences and insights of other teachers" (Loughran et al., 2006, p. 7). Alvarado (2010, p. 321) also stressed that "teacher education and

professional development can teach pre-service and in-service teachers to be intentional in their teaching and to think pedagogically", especially on how they can give students real world experiences.

The findings also indicated that teacher education is procedural, textbooks are procedural, and lesson planning requirements focus on the procedural. It is difficult for teachers to have a more conceptual understanding of what they need to do in class to achieve the goals of the curriculum. The universities and teacher training colleges could also introduce courses that have intensified PCK training, and also those that provide teachers with specific ideas or strategies on how to incorporate "difficult" topics into teaching, helping teachers develop or improve their PCK (Alvarado, 2010). The University of the Witwatersrand School of Education (WSOE) Department of Teaching Experience offers a course that aids the development of professional competence among student teachers, in particular, their pedagogical content knowledge (PCK). The course helps the student teachers to develop their capacity to make pedagogical choices that are logically derived from content and contextual knowledge. This can be a benchmarking opportunity for the Botswana institutions.

7.6.3. Implications for the Department of Curriculum Development and Evaluation

The Department of Curriculum Development and Evaluation is responsible for ensuring that the instructional materials used in the schools conform to the textbook, while the Development and Evaluation Committee evaluates and approves materials to be used at the different levels of Education, i.e. primary and secondary. There are some guideline provisions for the production of materials and these are selected on an author/publisher tendering system that determines the award of a publishing contract with the Ministry of Education and skills development. Textbooks are selected based on traits such as in-depth knowledge of the subject, expertise in the field, author's publishing record, experience in the field and membership of a recognised writers group. Book review committees were established to assist the Ministry in reviewing and evaluating the instructional materials. In chapter six of my study,

the findings from the textbooks indicated a gap in PCK in the resources for the students and teachers. This poses a challenge for the Department of Curriculum Development and Evaluation to ensure that the textbooks used by the teachers help and provide opportunities to construct PCK. Improved criteria for selecting textbooks should be set as the current criteria do not seem adequate. The current Primary and Junior Secondary Social Studies syllabi and the textbooks imply water management but the term 'conservation' is predominantly used. Since EE is no longer about conservation but about sustainability (Ketlhoilwe, 2007; Tema, 1999), this could indicate that the Botswana Department of Curriculum Development and Evaluation should update its curriculum to refer to sustainability so that is up to date with the current international trends.

7.7. Conclusion and suggestions for future research

My study focused mainly on exploring teachers' TSPCK on Water Resources and their Management in Botswana as well as their beliefs about EE and its teaching. My study focused on topic-specific knowledge and roles for teaching in EE, which emphasise the development of the "student's awareness, understanding and skills through student-centred methods" (Botswana Government, 1999). The findings of my study showed professed student-centred beliefs with regard to teaching in general and the teaching of EE in particular. The teachers indicate a belief in EE teaching that promoted participation in the environment and not only awareness. This demonstrated an understanding of the policy and goals for EE, both in Botswana and internationally. Although the teachers had pertinent beliefs about the wellbeing of the environment, knowledge of the environmental issues coupled with personal commitment, they were not able to transfer these beliefs into pedagogically appropriate decisions for teaching the topic of Water Resources and their management.

The teachers were informed and knowledgeable on water issues in the country. The teachers generally knew many facts on the topic water resources and their management, but were not able to impose a conceptual order on the facts they knew by identifying the big ideas that organised the content into meaningful units. Furthermore, once such 'big ideas' were given to

them, there was inconsistency in the extent to which they were able to develop those ideas into conceptually coherent units. The findings indicated that the teachers needed much support in working conceptually with the information given in the textbooks. They were very familiar with the basic facts and terminology but found it difficult to see the application to their own communities and the lives of students in their classes, thus the data also showed little evidence of enactment of EE.

Some aspects of their PCK, such as the appropriateness of the teaching strategies selected; the ways in which teachers chose to represent the content to the students in their classes were rudimentary at best. The findings showed that some of the components, like students' prior knowledge, were easier for the teachers to articulate than others. Although the teaching strategies provided by the teachers seemed to be student-centred, the teaching strategies did not seem to contribute to the goals of EE for motivating students to adopt sustainable lifestyles. EE promotes inquiry based learning but the teaching strategies provided by the teachers and in the textbooks that are at their disposal were more generic than directed towards attaining the goals of EE. There were limited tasks where students could critically examine their own water usage at homes, around the school and in their community. The implication would be that despite their adequate levels of TSPCK, teachers continue to face the challenge of effectively implementing EE in their classrooms. Since the study was focused on one particular topic, Water Resources and their Management, there are more opportunities to explore on teacher professional development.

The findings in my study showed that the beliefs teachers held about the environment, as well as those for EE teaching were articulated in terms of terminology used in the policy. However little evidence of these beliefs was found enacted in their CoRes and lesson plans. Teachers' lesson plans have often lacked consistency between the teachers' beliefs, intended outcomes, learning experiences and assessment tasks (Bozkurt and Kaya, 2008; Gooch et al, 2008).

This study contributes new knowledge in the area of teacher knowledge and PCK in EE particularly on Water Resources and their Management. Furthermore, the study adds to the

research literature on the relationship between subject matter and PCK, which is an area that has not been thoroughly researched in Botswana. There are few studies that have been done in Botswana on PCK hence the need for National or local longitudinal studies on the development of PCK among novice and expert teachers. Understanding teachers' practice in terms of PCK may be helpful in making explicit and refining teachers' professional learning about practice (Loughran, 2006, p. 17). It is important to explore "the parts of PCK that can be applied to any teacher in any teaching context for teaching a given topic" (Park & Suh, 2015, p.109). Such investigations would provide useful information that enhances teacher education.

In his book, Loughran (2006) argues that teachers need help to think about their practice and the reasons behind their actions as they teach their students. He suggests that creating Resource Folios, "a representation of PCK for a topic by illustration how ideas of a CoRe" and accounts of teachers' practice (PaP-eRs) will "offer teachers a powerful, accessible and useful representation of PCK" (Loughran, 2006, p. 26). Exploring PCK for different EE topics and creating Research Folios through research on EE topics can provide a knowledge bank for new teachers and those already in the service, and enable them to conceptualise different EE topics. More importantly, though, this study shows the disconnect between teachers' knowledge of the topic they teach, their knowledge of the students in their classes and the way in which they think about their teaching practices.

The findings in my study also indicated that the context of the students was important in the learning of topics on the environment; therefore it would be worthwhile to explore further the influence of Indigenous Knowledge (IK) on the learning of EE in Botswana. Indigenous knowledge refers to the "… complete bodies of knowledge, know-how, practices and representations that have been maintained and developed by generations of Batswana in their interaction with the environment" (GEF Small Grants Programme, 2008). Goduka (2005) asserts that it is important for people in the different communities to understand their cultural practices and philosophical backgrounds in order for them to understand their environment and achieve sustainable development. This knowledge is a reservoir of wisdom about cultural and environmental matters that originates from the daily life of the local population and its

continuity for other generations. The teaching of EE should therefore consider the context of the students being taught.

Most of the water management practices in Botswana fall short regarding water conservation and demand management, but instead focus more on the development of additional water supplies (Marandu et al, 2010; Toteng, 2008). The 'save water campaigns' by the Botswana Water Utilities Corporation, a government-owned corporation that provides water and waste water management services, only intensify when there is an acute shortage of water or during the drought seasons – there is an increase in media appearance on television, radio and in newspapers. These campaigns are usually ineffective and unconvincing; especially since the corporation is not keen on fixing leaking pipes that waste a lot of water in many parts of the country all year round. Until the country gets teacher knowledge and PCK right, these ineffective short term interventions will need to continue. There is need for meaningful and long term intervention regarding teachers' knowledge rather than ad hoc ineffective interventions that have been used up until now. Getting teaching right might be a more enduring and sustainable solution to educating Batswana about water resources. A more widespread use of CoRes could be useful to assist teachers in Botswana in engaging more substantively with the conceptual demands of the content they teach, and the grounds on which they select teaching strategies.

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APPENDICES

Appendix A: *Letter to Botswana Ministry of Education and Skills development*

School of Mining Engineering
Private Bag X3
Wits, 2050
Johannesburg
Cell: +27787989974

Emails: ludomphathiwa@yahoo.com
Or Ludo.Mphathiwa@students.wits.ac.za

20th November 2011

The Permanent Secretary
Ministry of Education and Life Skills Development
Private Bag 005
Gaborone
Botswana

Dear Sir,

RE: A REQUEST FOR PERMISSION TO CARRY OUT RESEARCH

My name is Ludo Mphathiwa from the Graduate School of Humanities at the Witwatersrand, School of Education in Johannesburg, South Africa. I am currently undertaking a research towards my Doctor of Philosophy (PhD) specialising in Curriculum and Instruction. I am exploring teachers' Subject Matter Knowledge (SMK) and Pedagogical Content Knowledge (PCK) in Environmental Education by examining how Social Studies Teachers in Botswana use and apply their understanding of the teaching of the topic Water Resources and Conservation in Botswana. The tittle for my study is "How Social Studies Teachers in Botswana use and apply their understanding of the teaching of the Topic Water Resources and Conservation". I am specifically interested in Social Studies teachers in the Junior Secondary Schools and those who are upgrading to B. Ed Secondary, and are now in their third and fourth year of study. I believe that their input and experience would be a very valuable source of information for me. I would therefore like to request your permission to pursue some research within the Secondary Schools of Botswana as well as invite the Junior Secondary Education Social Studies teachers to join the study.

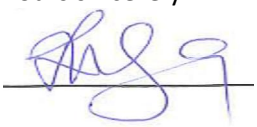
I will need the teachers to participate in a semi-structured interview, which should last about 45 - 90 minutes. The interview will be taped and transcribed for analysis. During this interview, teachers will be asked to share; their beliefs about teaching environmental topics (in this case on Water Resources and Conservation); lesson rationale; objectives for topic; difficulties / Limitations connected with topic; students' knowledge (pre and misconceptions) about topic; teaching methods planning strategies and materials to be used. They will also be asked to share what they consider to be the main ideas or concepts in teaching in the topic Water and how they would enable their students to understand these ideas.

Participation is voluntarily and participants may withdraw from the study at any time. They have the right to review the transcripts made of our conversation before these are used for analysis. Furthermore, they can decline to answer any question. At all times, the participants' names will be kept confidential; they will be identified by pseudonyms only. The people they may mention will also be kept confidential. The participants' may be quoted in the dissertation, but it will be done in such a way that their identity is not revealed.

The purpose of this research is to explore the understandings of Social Studies teachers of EE and/or ESD and establish how these understandings inform the way they approach topic on Water Resources and Conservation in Botswana in the country as well as how teachers respond to an intervention on effective teaching of topics on environmental resource utilisation. The study also seeks to explore teacher's beliefs about teaching and the teaching of EE and the extent to which domains of teacher knowledge are manifest in the teaching and learning of EE and/or ESD. By so doing the research strives to add knowledge and reinforce current environmental and sustainability education pedagogies. The thesis will be published, and the research generated may lead to seminars. It is my hope that the Social Studies teacher's input may help in the development of knowledge that could strengthen existing structures for teacher development in EE and/or ESD.

Should you need any further information, feel free to use any of the provided contact details. I am looking forward to your response in anticipation.

Yours sincerely



Mrs Ludo Mphathiwa
(Researcher)

Appendix B: *Beliefs Tool*

BELIEFS ABOUT TEACHING

1. What made you choose teaching as a career?

2. What do you love about the job?

3. What do you find challenging?

4. What would you say are the most important things that make someone an effective teacher?

5. How do you maximize student learning in your classroom?

6. A simile describes the characteristics of one thing with another. Think of a job that has something in common with being a teacher and explain your analogy?

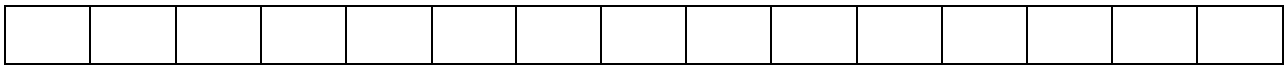
Being a teacher is like being a _____ because _____

7. Here is a list of statements about effective teachers. Decide if you agree, partially agree or disagree. If you don't agree, state your reason(s) in the space below each statement.

	An effective teacher…	Agree	Partially	Disagre
I.	Keeps students quiet and orderly during a lesson.			
II.	Tells students the information they need to know.			
III.	Keeps the students doing their work until the end of the period.			
IV.	Thoroughly understands the topic of the lesson.			
V.	Has everything organized and doesn't waste time during the			
VI.	Asks students if they all understand, after the explanations.			
VII.	Marks their class work and checks that students get the right			
VIII.	Reflects on how each lesson went to learn from experience			
IX.	Delivers each lesson within the allocated time period			
X.	Knows how students will probably understand and			
XI.	Has a friendly and warm relationship with student s			
XII.	Prepares for lessons by memorizing the facts that student s			
XIII.	Has a clear idea of the purpose of each lesson and what student			
XIV.	Connects the lesson to what the student s already know			

Now take the comments that you agreed with. Rank their numbers in order of importance.

Most important → Least important



8. How do you know when your students understand?

9. How do your students learn best?

Appendix C: *Teacher questionnaire*

PART I: BACKGROUND INFORMATION

This info is for research purposes only: your responses will be treated confidentially. This page will be detached and stored separately.

Name: _____ Surname: _____

Gender (tick✓): Female _____ Male _____

Please fill in details of all qualifications after you left secondary school.)

Qualification	From (year)	To (year)	Subject/s specialisation

Please provide the following information about your teaching experience.

Number of years	School and region	Subjects taught	Classes taught

Please provide information on any pre -service training on Environmental education, either courses or workshops in environmental teaching methods, ecology, or other environmental studies.

Course/workshop	Yes (✓) No (×)	Hosts of the Course / workshop
Environmental education teaching methods		
Ecology		
Environmental studies		

PART II: ENVIRONMENTAL ISSUES

1. Please indicate whether you disagree or agree with each of the following statements about the environment by ticking (tick✓):

Statements about the environment	**Strongly Agree**	**Agree**	**Not sure**	**Disagree**	**Strongly disagree**
The earth has plenty of natural resources if we just learn how to develop them					
Plants and animals have as much right as humans to exist					
The balance of nature is strong enough to cope with the impacts of modern industrial nations					
The earth is like a spaceship with very limited room and resources					
Humans were meant to rule over the rest of nature					
The balance of nature is very delicate and easily upset					
The so-called ecological crisis facing humankind has been greatly exaggerated					
If things continue on their present course, we will soon experience a major ecological catastrophe					
I am very concerned about the environmental issues in my own community					
I am very concerned about global environmental issues					

1 (a). If you strongly disagree with any of the above statements, you may explain your position.

PART III: *WATER MANAGEMENT IN BOTSWANA*

2. Which of the following environmental problems affect your community? Please indicate your answer with a tick (✓):

Environmental problem	
Waste disposal	
Water quality	
Water quantity	
Soil degradation	
Air pollution	
Alien vegetation	
Habitat destruction	
Energy	
Endangered animals and plants	

3. What are the main concerns and/or issues that your community has about their water supply and quality, if any?

4. Do you think that Botswana should be concerned about the availability and quality of water resources? Why or why not?

5. What do you think are the most important threats to water resources in Botswana?

6. If you were to make recommendation/s to the Government of Botswana, on ways of ensuring sustainable water quality and supply, what would you recommend?

7. What do you think about the recycling of sewage water as an option of water management in Botswana? Explain your answer.

PART IV: TEACHING OF WATER RESOURCES AND CONSERVATION

8. Why do we teach children about the environment? Please indicate your answer with a tick (✓):

Children need to:	**Very Important**	**Somewhat important**	**Not important**
Understand how people and their environment are connected			
Understand different views on environmental issues			
Gain basic knowledge of environmental concepts			
Understand natural processes			
Develop awareness of important environmental issues			
Develop an appreciation of the natural environment			
Be aware of their responsibility for looking after the environment			
Learn what individuals can do to make a difference			
Understand the impact of one's choices and decisions on the environment			
Behave in an environmentally responsible manner			
Take action to improve environmental quality			
Become aware of one's responsibility to the earth			
Improve communication skills			
Improve critical thinking skills			
Improve self esteem			
Improve problem solving skills			

9. What does it take to be an effective environmental education teacher?

10. What do students need to know before they can understand the management and conservation of water resources?

11. Why is it important for students to learn about the management and conservation of water resources?

12. What are with the challenges of teaching about the management and conservation of water resources?

13. What common misunderstandings do you think children might have about water resources and their management?

Appendix D: *Composite CoRe Template (Water Resources and their Management in Botswana)*

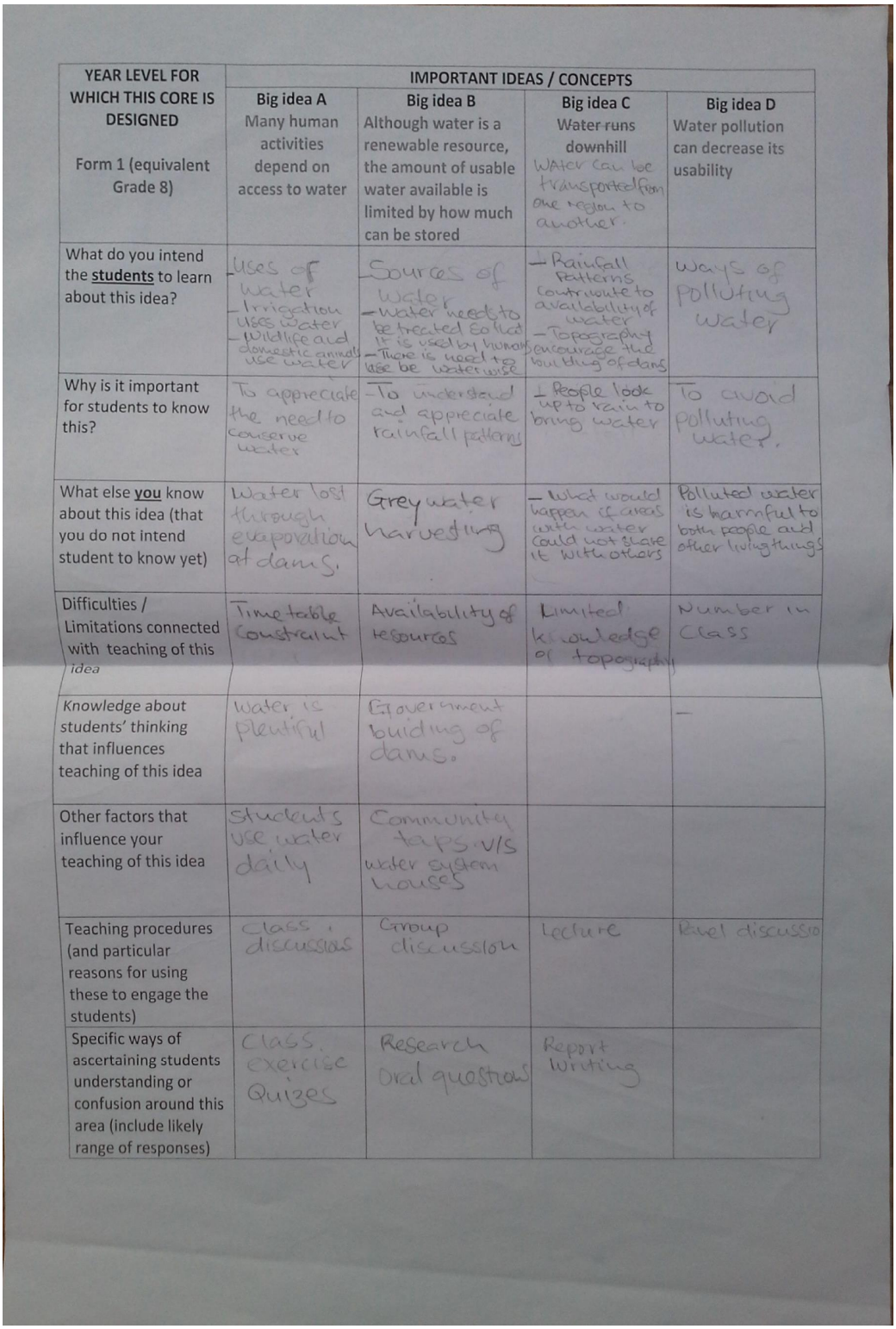
YEAR LEVEL FOR WHICH THIS CORE IS DESIGNED Form 1 (equivalent Grade 8)	IMPORTANT IDEAS / CONCEPTS			
	Big idea A **Many human activities depend on access to water**	**Big idea B** **Although water is a renewable resource, the amount of usable water available is limited by how much can be stored**	**Big idea C** **Water can be transported from one region to another**	**Big idea D** **Water pollution can decrease its usability**
What do you intend the **students** to learn about this idea?	- Uses of water in Botswana - Sources of water and availability - Importance of water - Water demand categories in Botswana and estimated water demands by sector 1990 – 2020	- Water Sources in Botswana (their importance capacity, water reaching dam storage (ground and surface) - The National water Master Plan (rapid water increase demand in Botswana, challenges of developing water surface resources, low recharge rates of underground water, poor quality of water, high evaporation) - Water conservation practices in Botswana (reduced consumption, reuse of waste water, rainwater harvesting)	- Water flows across the globe regardless of boundaries (water cycle, run off) - We share some of our water sources with other countries - The way we use water can affects the quality and quantity of water in other countries downstream (i.e. amount of water, trans boundary water borne diseases) - It is necessary for countries to share info i.e. upstream and downstream about water issues - National water Master Plan (Design of transfer schemes and pumping water for distribution, dam construction constraints in Botswana are mainly due to the flat topography) - Problems of internationally shared water resources	- Sources of pollution (e.g.) nitrates, hazardous waste not properly disposed, chemicals and fertilizers - Types of pollution (artificially and naturally occurring) - Ways of reducing pollution (prohibiting use of pit latrines, ensuring usage of sewage systems, employing improved waste management strategies in both industrial and domestic areas, privatisation of waste management)
Why is it important for students to know this?	- To **create awareness** and appreciation of water as an important resource in our lives and that it is an important resource for human economic activities and the country's development - **To emphasise** the point that we need water for survival - To promote **attitudinal change** and reflection on their **actions**	- **Sensitising** students on the challenges of government in providing Batswana with portable water as well as implications on expenditure (thus developing water resources is expensive and is yet to increase as the demand grows) - Making them **aware** that some of the water we drink is from other countries hence they may appreciate the need to use water wisely - Promote sustainable use of water and **attitudinal change**, thus promote **participation** in water conservation **ALL**	- So they **know** that Water is an internationally shared resource - **Awareness t**hat Water runs downhill, so the way we use water can affect the quality and quantity of water in other countries - To create an understanding in the influencing factors/basis for dam construction and transfer schemes	- So they **know** that: • Polluted water may not be usable • Polluted water can be hazardous to people's lives • Some human activities can affect the quality of water • solutes dissolved in water do not evaporate" and so polluted water tends to become increasingly

				salinised - Make student s custodians of a safer environment - To avoid water pollution
What else **you** know about this idea (that you do not intend student to know yet)	- The National Water Master Plan (its' rationale and objectives) - Effects on urbanisation and industrialisation on supply of water - That grey water can be recycled and be used to improve water quantity K	- National water master plan only caters up to 2020 - The nature of water scarcity in Botswana is not seasonal but also varies with periodic droughts - Botswana is located between 18 and 27 degrees, which is characterised by high pressure in winter. This is a dispersal mechanism that promotes clear skies, so no rain in winter. - This situation is aggravated by recurrent droughts - Atmospheric conditions in this system are difficult to predict (ref. Atlhopheng, 1998)	- National wetland policy - Regional conventions on shared water resources - Ramsar, SADC Protocol, Permanent Okavango River Basin Commission (OKACOM), Limpopo River Basin Committee and the Bilateral Water Commission	- Naturally occurring pollutants - That usable water is also limited by contamination form flooded boreholes - Stagnant water can also be hazardous i.e. can cause diseases - That certain industrialised countries dump toxic waste in seas and shores killing Marine life -
Difficulties / Limitations connected with teaching of this idea	- Students may take availability of water for granted if they live in an area of good water supply hence difficult to be convinced that water is a scarce resource - Inadequate textbooks - Insufficient information in prescribed core texts - Timetabling which prevents learning outside the classroom - Curriculum design - which promotes objectivity	- Students attitudes towards water sustainability - Language barrier may limit students understanding of main concepts especially those who use English as third language - Logistical constraints like (Time table constraints **,** Timetabling which prevents learning outside the classroom, Inadequate textbooks, Insufficient information in prescribed core texts)	- Proximity to areas used as examples in the lesson may make the information far-fetched for some student s and thus may not make sense - Students' negative attitude towards water conservation, this attitude is difficult to deal with - Logistical constraints like (Time table constraints **,** Timetabling which prevents learning outside the classroom, Inadequate textbooks, Insufficient information in prescribed core texts, little support from school management to do field work)	- In areas with less generation of waste, it may not be easy convincing pupils about contamination - convincing students that pit latrines leads to contamination of water Logistical constraints like (Time table constraints **,** Timetabling which prevents learning outside the classroom, Inadequate textbooks, Insufficient information in prescribed core texts)
Knowledge about students'	- Students think that water comes from the tap and can	- They know that water is an essential resource to people **N**	- **Traditional beliefs** and myths that student s bring to class (it will always rain	- Students think that polluted water is dirty water and that

thinking that influences teaching of this idea	never finish - They think that water will always be available as long as it rains - They also think that it will always rain every year and so there will be plenty of water - They think that Botswana has abundant water of water in dams, rivers, boreholes and at the Okavango delta - Water is not scarce (especially for those students who come from the wetland areas with plenty surface water - Their values and beliefs may limit / influences the understanding of the concept	- Attitudes that - water is infinite, water wasted in their homes will be replaced during the rainy seasons) - Traditional beliefs and myths that student s bring to class (it will always rain as long as the god's have been appeased –rainmaking and praying for rain) - students lack of knowledge and understanding on shortage of water particularly in rural areas - Student s from different cultural backgrounds (rural areas vs urban)	as long as the god's have been appeased –rainmaking and praying for rain) - **Attitudes** that - water is infinite, water wasted in their homes will be replaced during the rainy seasons) - they think that Botswana has abundant water at the Okavango delta and that it is our water alone - **Lack of knowledge** of some concept by teacher -	when the water is clear, it is clean - They think pollution is caused by throwing contaminated materials into the water, overlooking that land pollution also contaminates water through runoff - They don't understand that air pollution also contributes to water pollution e.g. acid rain - The students don't see the link between water and waste
Other factors that influence your teaching of this idea	- This is a new topic in the syllabus and the teacher has insufficient content knowledge on water issues - traditional knowledge and methodologies used by teacher does not promote diversity in dealing with environmental issues - logistical constraints (lack of resources, curriculum design, Lack of support from the management to do projects)			
Teaching procedures (and particular reasons for using these to engage the students)	- Student will outline the different water uses in the different regions of Botswana. The teacher will use the Jigsaw collaborative instructional strategy to create groups so that each group can have representatives to bring back some feedback. - Student will be provided with tables and work in groups to identify the sectors that need/use more water (e.g. domestic)	- Activity to identify and describe the water sources in the country. - Students establish what makes water usable - Students describe the issue of storage - Students watch a video on "being water wise and asked to identify observed conservation practices from the video. - They are also given a mini case study scenario on two families and their different water usage and analyse to establish which one is being water wise -	- Students are divided into 7 groups and each assigned a sub topic to research on basing on the intended learning outcomes and each present to the class - Site visits to place – water pumping station and areas of severe water wastage - Show video on water purification and transportation	- Students do a water assessment test on different water samples from different water sources - they test for acidity/alkalinity, check for forms of life (e.g. insects, algae)in the water samples and what their findings imply with regard to the state of the water - Mini research to fully involve student s and ensure they link with the environment and expose the

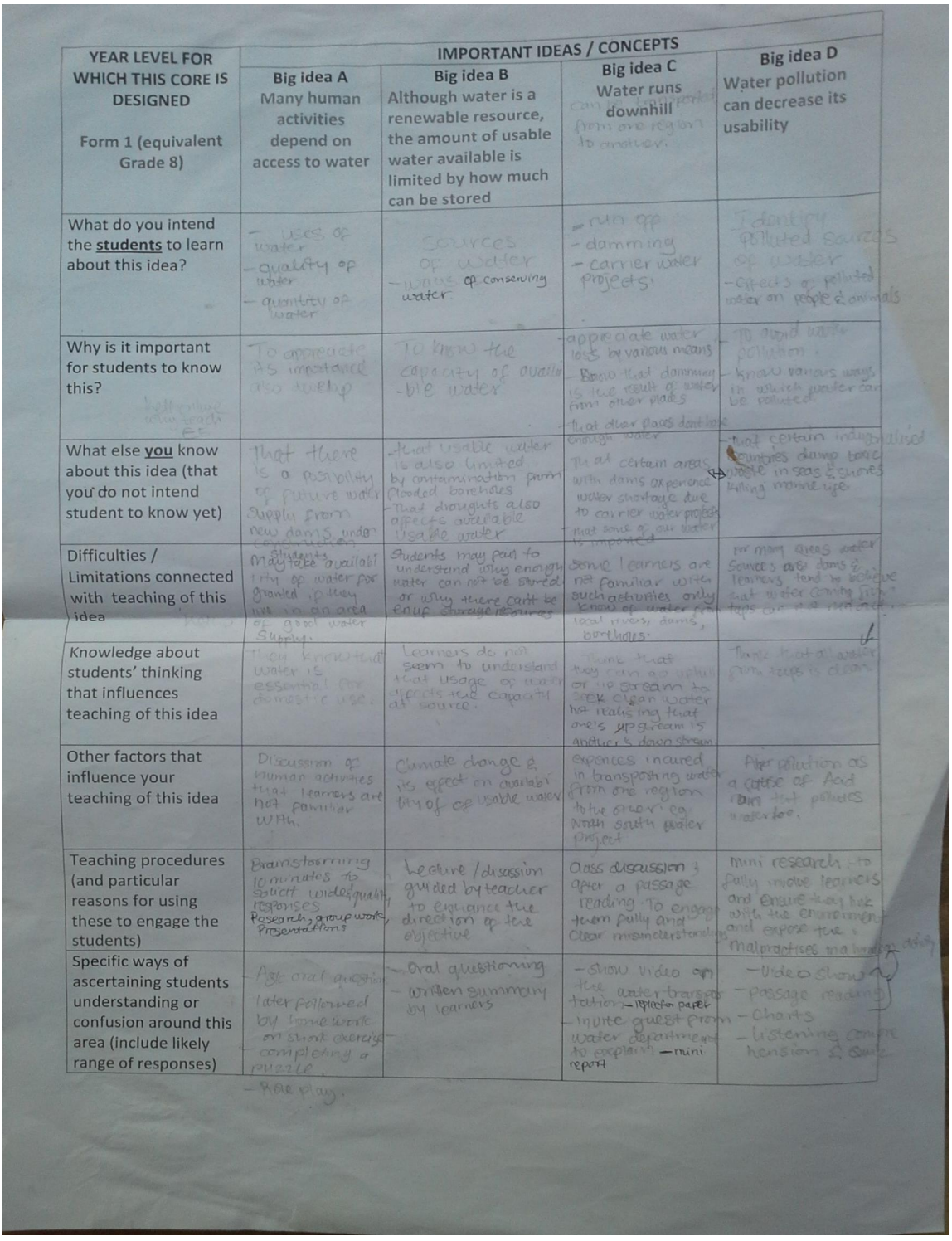
				malpractices and water mismanagement in a hands on activity - Identify a problem in school and address it even if they involve water authorities in their community - Write reflection papers or mini reports on the issues addressed by the guest speaker from the department of water
Specific ways of ascertaining students understanding or confusion around this area (include likely range of responses)	- Students will be provided with incomplete tables to complete - They will be asked to answer questions in the form of a quiz on the water demand areas in Botswana	- Students are given a mapping activity on the current and proposed future water sources (ref Silitshena, 1989, p. 43). - Students' debate. Possible tittles for the debate will be as follows: e.g. Waste water should be recycled and put back in the taps for use Future generations are at risk of having no water to use Water is factor 1 of economic development - Students are given a mini project to conduct in groups. They do an audit of the water use in their school using the water footprint and then come up with recommendations on ways to improving water use in the school	- The teacher initiates an oral question and answer exercise and prepares a quiz for them to attempt	- Students write a summative test with both multiple choice questions and open ended questions on water pollution - formation of advisory club on environmental issues - - observing for sign of behavioural change and participation in water conservation practices

Appendix E: *Felicia's initial CoRe*



YEAR LEVEL FOR WHICH THIS CORE IS DESIGNED Form 1 (equivalent Grade 8)	IMPORTANT IDEAS / CONCEPTS			
	Big idea A Many human activities depend on access to water	**Big idea B** Although water is a renewable resource, the amount of usable water available is limited by how much can be stored	**Big idea C** Water runs downhill Water can be transported from one region to another.	**Big idea D** Water pollution can decrease its usability
What do you intend the **students** to learn about this idea?	-Uses of water -Irrigation uses water -Wildlife and domestic animals use water	-Sources of water -Water needs to be treated & filtered if it is used by humans -There is need to use be water wise	-Rainfall patterns contribute to availability of water -Topography encourage the building of dams	Ways of polluting water
Why is it important for students to know this?	To appreciate the need to conserve water	-To understand and appreciate rainfall patterns	-People look up to rain to bring water	To avoid polluting water.
What else **you** know about this idea (that you do not intend student to know yet)	Water lost through evaporation at dams.	Grey water harvesting	-What would happen if areas with water could not share it with others	Polluted water is harmful to both people and other living things
Difficulties / Limitations connected with teaching of this *idea*	Timetable constraint	Availability of resources	Limited knowledge of topography	Number in class
Knowledge about students' thinking that influences teaching of this idea	Water is plentiful	Government building of dams.		-
Other factors that influence your teaching of this idea	Students use water daily	Community taps V/S water system houses		
Teaching procedures (and particular reasons for using these to engage the students)	Class discussions	Group discussion	Lecture	Pixel discussio
Specific ways of ascertaining students understanding or confusion around this area (include likely range of responses)	Class exercise Quizes	Research Oral questions	Report writing	

Appendix F: *Irene's initial CoRe*



YEAR LEVEL FOR WHICH THIS CORE IS DESIGNED Form 1 (equivalent Grade 8)	IMPORTANT IDEAS / CONCEPTS			
	Big idea A Many human activities depend on access to water	**Big idea B** Although water is a renewable resource, the amount of usable water available is limited by how much can be stored	**Big idea C** Water runs downhill	**Big idea D** Water pollution can decrease its usability
What do you intend the **students** to learn about this idea?	- uses of water - quality of water - quantity of water	sources of water - ways of conserving water	- run off - damming - carrier water projects	Identify polluted sources of water - effects of polluted water on people & animals
Why is it important for students to know this?	To appreciate its importance also to help	To know the capacity of available water	- appreciate water loss by various means - know that dammimg is the result of water from other places - that other places don't have enough water	- To avoid water pollution - know various ways in which water can be polluted
What else **you** know about this idea (that you do not intend student to know yet)	That there is a possibility of future water supply from new dams under construction	- that usable water is also limited by contamination from flooded boreholes - that droughts also affects available usable water	- that certain areas with dams experience water shortage due to carrier water projects - that some of our water is imported	- that certain industrialised countries dump toxic waste in seas & shores killing marine life
Difficulties / Limitations connected with teaching of this idea	Students may take availability of water for granted if they live in an area of good water supply.	Students may fail to understand why enough water can not be saved or why there can't be enough storage reserves	some learners are not familiar with such activities only know of water from local rivers, dams, boreholes.	in many areas water sources are dams & learners tend to believe that water coming from taps are ...
Knowledge about students' thinking that influences teaching of this idea	They know that water is essential for domestic use.	Learners do not seem to understand that usage of water affects the capacity at source.	Some think that they can go uphill or upstream to seek clean water not realising that one's upstream is another's downstream	Think that all water from taps is clean
Other factors that influence your teaching of this idea	Discussion of human activities that learners are not familiar with.	Climate change & its effect on availability of usable water	expences incured in transporting water from one region to the other eg North south water project	After pollution as a cause of Acid rain that pollutes water too.
Teaching procedures (and particular reasons for using these to engage the students)	Brainstorming 10 minutes to solicit wide/quality responses Research, group work, Presentations	lecture / discussion guided by teacher to eglance the direction of the objective	class discussion after a passage reading. To engage learners fully and clear misunderstandings	mini research - to fully involve learners and ensure they link with the environment and expose the malpractises ...
Specific ways of ascertaining students understanding or confusion around this area (include likely range of responses)	Ask oral question later followed by homework on short exercise completing a puzzle. - Role play.	- Oral questioning - Written summary by learners	- Show video on how water transportation - Plasticine paper - Invite guest from water department to explain - mini report	- Video show - Passage reading - Charts - Listening comprehension

Appendix G: *Naledi's initial CoRe*

YEAR LEVEL FOR WHICH THIS CORE IS DESIGNED Form 1 (equivalent Grade 8)	IMPORTANT IDEAS / CONCEPTS			
	Big idea A Many human activities depend on access to water	**Big idea B** Although water is a renewable resource, the amount of usable water available is limited by how much can be stored	**Big idea C** Water runs downhill	**Big idea D** Water pollution can decrease its usability
What do you intend the **students** to learn about this idea?	-uses of water -sources of water -quality of water -quantity. industrial uses domestic uses	understand environmental issues and problems affect water supply.	Contamination of water from one area to the other	effects of high population on water resources -Disposing of sewage water. -Urbanisation & pressure on waste water. -Industrial activities that affect/pollute water. -wise disposal & Pollution of water bodies
Why is it important for students to know this?	Promote awareness understand the importance of water to livelyhood. -take action in conserving water. -change of attitudes	take a deliberate action towards water conservation -To connect to the environment in a positive way.	reflect on their activities that affect the safety & supply of water -Reflect on ones activity on water can affect the ecosystem	engage learners in mini projects aimed at conserving water resources -engage learners in educating the community. -make learners cultivating of a safer environment Teaching Methods
What else **you** know about this idea (that you do not intend student to know yet)	Some Research that are still mislead learners.		on going which may	Pollution of water by mercury that escape from buildings/homes.
Difficulties / Limitations connected with teaching of this idea	Information may seem irrelevant to learners who come from places with plenty of water. thus the diversity of learners may send diff messages to learners	Language barrier may limit students understanding of main concepts esp those who use English as third language. Regional variation may also limit knowledge	Proximity to ~~not~~ areas used as examples in the lesson may make the information far fetched for some learners & thus may not make sense.	Some learners may have been exposed to unsafe water for as long as they lived therefore may not see why this suddenly become a problem.
Knowledge about students' thinking that influences teaching of this idea	Their values & believes may limit/influences the understanding of the concept.			~~Poss~~
Other factors that influence your teaching of this idea	Government policy on usage of water. How much the teacher know about this Concept.	lack of motivation by the employer. interest of the learner in the subject Number of students in class	Knowledge of the concept. Support from School management to do field work.	Support from the management to do projects. Availability of finances to carryout some projects
Teaching procedures (and particular reasons for using these to engage the students)	Role play. Field work Inquiry/reports. Dramatisation	help learners connect and understand it better hands on.	learners connect to the environment when they are	Research projects.
Specific ways of ascertaining students understanding or confusion around this area (include likely range of responses)				

Appendix H: *Naledi's Lesson Plan*

RATIONALE FOR LESSON DESIGN

SECTION 1: Routine information

Form: 1 Subject: SOCIAL STUDIES

Theme: WATER POLLUTION Duration: 80 minutes

Subject: _____ Topic: WATER CONSERVATION PRACTICES

Sub – topic: THE EFFECTIVENESS OF WATER CONSERVATION PRACTICES IN BOTS.

Sub – topic for the topic that came before: Factors affecting water resources in the country

Sub – topic for the topic that will follow: N/A

SECTION 2: Purpose of the lesson

Key Questions *(2 -3 most important questions learners should be able to answer after this lesson)*

- Which water conservation practices are used in your village
- What critical uses of water can be affected by shortage in your village
- What practice can lead to damage of water

Skills *(What should the pupils learn how to do during the lesson?)*

During this lesson, learners will learn how to ....

Assess water conservation practices
Investigate factors affecting water quantity and quality

Attitudes and values *(What does this lesson promote as being good or just or fair?)*

A sense of accountability and willingness by participants to water conservation.

SECTION 3: Content knowledge for the lesson *(Summarise your understanding of the most important content knowledge of this lesson)*

- That pupils should have knowledge of water conservation practices and be able to assess their effectiveness

SECTION 4: Learner factors to consider in relation to topic *(learner diversity, prior knowledge, subject vocabulary, examples for better understanding, evidence of understanding to be produced, misunderstandings/mistakes and ways of pre emptying student possible misunderstandings)*

- Learner diversity since they come from different cultural background and different learning abilities.

SECTION 5: Teaching and learning strategies *(most suitable strategies for this topic, what classroom tasks could deepen student understanding of topic)*

- Group discussions
- Video showing
- Investigation and project

SECTION 6: Sequence of lesson steps

Aim of lesson step	Time allocated	Describe what will happen in each lesson step *(learning activity)*	Resources needed
1. To: Identify main Sources of water resources and discuss the importance of Water Resources.	15min 15min	Pupils will work in small groups and identify main sources of water resources and using Provided work cards, discuss the importance of water resources to humanity. - Pupils will make a presentation with each group given an opportunity.	Work cards - Posters - Writing Paper Text book
2. To: Explain the challenges faced in the effort to provide Portable water to different areas and Suggest better conservative strategies/Practices.	15min 15min	- Pupils will watch a video for 5min. The still working in their groups will describe what they learned as challenges faced in trying to provide portable water in Botswana. - Pupils will use Posters to identify other factors affecting water quality in Botswana	Video by water wise. - Posters - Writing Paper -Text book
3. To: Discuss the dangers of Poor waste management with regard to the quality of water. Conclussion	10min 10min	Pupils will discuss with the teacher, the dangers of Poor waste management on the quality of water resources Pupils will respond to to questions addressing the main areas of the topic as a conclussion and evaluation	Chalkboard -Question Papers

Appendix I: *Kagiso's Lesson Plan*

RATIONALE FOR LESSON DESIGN

SECTION 1: Routine information

Form: 1 Subject: SISTUDIES

Theme: WATER Duration: 80 MINS

Subject: Topic: WATER RESOURCES & CONSERVATION

Sub – topic: Water Conservation Practises in Botswana

Sub – topic for the topic that came before: Factors affecting water Resources in Botswana

Sub – topic for the topic that will follow:

SECTION 2: Purpose of the lesson

Key Questions (*1 -3 most important questions learners should be able to answer after this lesson)*

- What are ways of conserving water.
- What observations have you made on water wastage
- Name water sources in Botswana

Skills *(What should the pupils learn how to do during the lesson?)*

During this lesson, learners will learn how to .....

- Assess the strategies used for observing water
- Practise ways to conserve water in Botswana

Attitudes and values *(What does this lesson promote as being good or just or fair?)*

- Promote positive attitude towards handling of water (be waterwise)
- Value water as an important a scarce resource

SECTION 3: Content knowledge for the lesson *(Summarise your understanding of the most important content knowledge of this lesson)* Lesson notes.

Strategies for conserving water

- Reduce, Reuse and recycle
- Strict water charges
- Enacting laws/Policies
- Use of water saving devices
- Construction of dams
- Public education & awareness

SECTION 4: Learner factors to consider in relation to topic *(learner diversity, prior knowledge, subject vocabulary, examples for better understanding, evidence of understanding to be produced, misunderstandings/mistakes and ways of pre emptying student possible misunderstandings)*

- Prior knowledge
- Learner diversity
- Subject vocabulary
- Learner interest

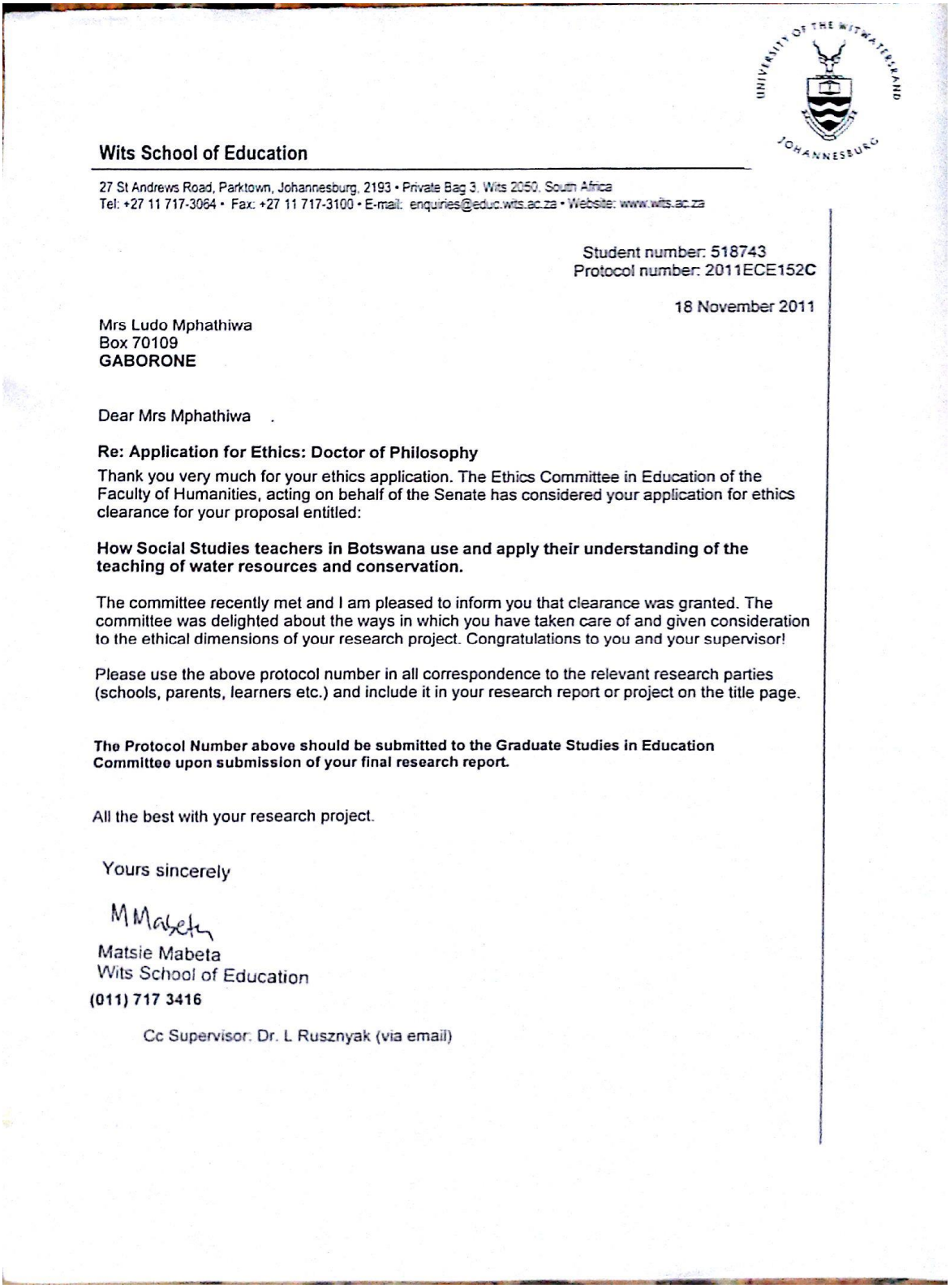
SECTION 5: Teaching and learning strategies *(most suitable strategies for this topic, what classroom tasks could deepen student understanding of topic)*

- Video Clip
- Mini project (Research
- Group discussion & Presentation
- Reading
- Quizzes

SECTION 6: Sequence of lesson steps

Aim of lesson step	Time allocated	Describe what will happen in each lesson step *(learning activity)*	Resources needed
1. Introduction Arouse learner interest	10 minutes	Watch video - From the video student should identify negative practices on water - Give definition of water conservation	Video Chalkboard
2. Development step 1 (Group discussion) - Interaction and team work share ideas to broaden their understanding - Promote critical thinking. - Presentation	30 minutes 20 minutes 10 mins	Group discussion using different charts to come up with water conservation strategies & possible ways of enhancing them, Presentation - Teacher stress on main points	Charts papers for recording group ideas
3. Conclusion - To evaluate student's understanding of concepts so that remediation can be prepared	10 mins	Quiz ① List different uses of water in homes ② Identify water sources ③ Identify ways through which water is polluted and suggest possible ways of solving that	Chalkboard exercises pupils

Appendix J: University of the Witwatersrand Human Research Ethics Committee clearance certificate



Wits School of Education

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Student number: 518743
Protocol number: 2011ECE152C

18 November 2011

Mrs Ludo Mphathiwa
Box 70109
GABORONE

Dear Mrs Mphathiwa .

Re: Application for Ethics: Doctor of Philosophy

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate has considered your application for ethics clearance for your proposal entitled:

How Social Studies teachers in Botswana use and apply their understanding of the teaching of water resources and conservation.

The committee recently met and I am pleased to inform you that clearance was granted. The committee was delighted about the ways in which you have taken care of and given consideration to the ethical dimensions of your research project. Congratulations to you and your supervisor!

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely

M Mabeta

Matsie Mabeta
Wits School of Education
(011) 717 3416

Cc Supervisor: Dr. L Rusznyak (via email)

Appendix K: *Participant Consent form*

Research Tittle: **HOW SOCIAL STUDIES TEACHERS' IN BOTSWANA USE AND APPLY THEIR UNDERSTANDING OF THE TEACHING OF WATER RESOURCES AND CONSERVATION**

I, _____ (consent /do not consent) to participate in this study conducted by Ludo Mphathiwa (518743) for a research thesis investigating the teachers' Subject Matter Knowledge (SMK) and Pedagogical Content Knowledge (PCK) in Environmental Education.

- I realise that the research is being conducted for educational purposes.
- I participate voluntarily and I may withdraw from the study at any time.
- I also have the right to review the transcripts made of our conversation before these are used for analysis, if I so choose.
- Everything I say will be kept confidential by the researcher.
- I will only be identified by a pseudonym in the thesis.
- Quotes from my interview sessions (may / may not) be used in the thesis. If used, they will be reported in such a way that my identity remains anonymous.
- Any specific individuals I refer to will be given a pseudonym.
- I understand that the dissertation will be published, but my identity will remain anonymous.

Signature: _____

Date: _____

Appendix L: *Consent from Botswana Ministry of Education and Skills development*

MINISTRY OF EDUCATION
AND SKILLS DEVELOPMENT

TELEPHONE: (267) 3901263
FAX: (267) 3975899

Republic of Botswana

Director, Regional Operations
South East
Private Bag 00343
GABORONE
BOTSWANA

SER 1/15/2 V (41)

10 January 2012

Mrs. Ludo Mphathiwa
Private Bag X3 WITS, 2050
Johannesburg
South Africa

Dear Madam

REQUEST FOR ASSENT TO CARRY OUT RESEARCH

The above matter refers.

You are granted permission to conduct your study in sampled schools in Gaborone to address the following research topic:

"How social studies teachers in Botswana use and apply their understanding of the topic Water Resources and Conservation."

You are expected to abide by the conditions as set by the Permanent Secretary, Ministry of Education and Skills Development by sticking to your research topic.

By this copy, school heads of your sampled schools are requested to assist you.

Yours faithfully

M. Tshetlhana
For **ACTING DIRECTOR – SOUTH EAST REGION**

TELEPHONE: 3655473
TELEX: 2944 THUTO BD
FAX: 3185167
REFERENCE E 1/20/ 2 XIII (8)

MINISTRY OF EDUCATION
PRIVATE BAG 005
GABORONE
BOTSWANA

REPUBLIC OF BOTSWANA

22nd December 2011

To: Ludo Mphathiwa
P/Bag X3
Wits, 2050, Johannesburg
South Africa

RE: REQUEST FOR A PERMIT TO CONDUCT A RESEARCH STUDY

We acknowledge receipt of your application to conduct a research study. This serves to grant you permission to conduct your study in sampled schools in Gaborone and Jwaneng to address the following research topic/objectives:

To: Explore the understanding of social studies teacher of Environmental Education and how these understanding inform the way they approach topics on water resources and conversation in Botswana

It is of paramount importance to seek Assent and Consent from the Department of secondary education, principals as well as teachers and students you are going to interview, observe as well administering questionnaires. We hope and trust that you will conduct the study as stated in your Proposal and to strictly adhere to the Research Ethics. Failure to Comply, with the above Regulations will result in Immediate Termination of the Research permit.

Please note that this permit is valid for a period of one year effective from 22nd December 2011 to 22nd December 2012.

You are furthermore requested to submit a copy of your final report of the study to the Division of Planning, Statistics and Research, Ministry of Education, Botswana.

Thank you in advance.

Yours faithfully

F.T Siamisang
For / Permanent Secretary

SAVINGRAM

FROM: Acting Director
Secondary Education

B.S. Kauraisa
For Acting Director

TEL: 3656100
FAX: 3973 890

TO: To the School Head
Southern Schools

REF: SE 1/15/2 I(29) 9th January 2012

RE: RESEARCH STUDY REQUEST

This serves to introduce Mrs Ludo Mphatiwa who wishes to conduct some research into teacher understanding of water conservation is part of her doctorate.

Please allow her access to your school and teachers.

Thank you.

BSK/ndn

Appendix M: *Guidelines for quantifying PCK – based on CoRe's*

PCK Components	(1) Limited	(2) Basic	(3) Developing	(4) Exemplary
Curricular Saliency	• Identified subordinate ideas and pre-concepts are a mix with those of other topics or no subordinates provided • Sequencing no value due to mixed concepts • Reasons given for importance of topic limited to general benefit of education • Inaccurate content or misunderstands big idea • Possible sources of confusion not identified	• Not all 4 Big ideas have subordinate concepts identified however those identified are correct • Sequencing can be followed however has one illogical placing of key concepts (Big Ideas) and also for the suggested pre-concepts. • Reasons given for importance of topic exclude conceptual considerations such as scaffolding/sequential development of understanding for other topics in the subject. • Knowledge often limited to what student s need to know • Possible sources of confusion not identified	• Identifies correct subordinate ideas and shows links to Big ideas with no additional explanations • Provides logical sequence of concepts of some of the Big Ideas within reason • Identified pre-concepts includes those used in the definition of current topic • Reasons given for importance of topic include reference to conceptual scaffolding/sequential development of understanding of other topics in the subject without specifying the topics • Research evident, demonstrates sound understanding of topics beyond what student s need to know • Identifies possible sources of conceptual confusion at a surface level	• Identifies correct subordinate ideas and explains links to Big Ideas • Provides logical sequence of concepts of all the Big Ideas and pre-concepts logical within reason • Identified pre-concepts include those needed in discussing the introductory definitions and those sequentially needed in the next Big Ideas of the current topic. • Reasons given for importance of topic include conceptual scaffolding/sequential development of understanding for specified subsequent topics in the subject. • Comprehensive, well organised knowledge of topics; foregrounds main ideas; networked examples • Identifies possible sources of conceptual confusion
Student Prior Knowledge including misconceptions	Not perceptive of student s needs / No identification, acknowledgement/ No consideration of student prior knowledge or misconceptions	• Identifies misconception or prior knowledge on one big idea only • Aware of student s needs but not able to find appropriate balance	• Identifies misconception or prior knowledge on two or more big ideas • Provides the basis and reasons for the consistent students' knowledge • Aware of student s needs; considers their context and diversity	• Identifies misconception or prior knowledge on all big ideas • Provides the basis and reasons for the consistent students' knowledge • Identifies and considers diversity in students' ability, learning style, interest, developmental level and need. • Confronts misconceptions/confirms accurate understanding Subtle understanding of student strengths and weaknesses
Representation Explicitly in CoRes	• Limited to use of analogies, demos, etc.) representation with no explanation of specific links to the concepts represented	• Describes or demonstrates ways to model or illustrate a concept (analogies, demos, diagrams etc.) and use of representation without explanatory notes to make the links to the aspects of the concept being explained (For only one big idea) • .	• Describes or demonstrates ways to model or illustrate a concept (analogies, demos, diagrams etc.) and use of representation with explanatory notes linking the two representation to the aspect(s) of the concept being explained (For more than one big idea) •	• Describes or demonstrates ways to model or illustrate a • concept (analogies, demos, diagrams etc.) or symbolic representation and • Use of <u>detailed</u> representation to enforce a specific aspect (s) of the concept being explained

PCK Components	(1) Limited	(2) Basic	(3) Developing	(4) Exemplary
What makes topic difficult to teach	• Leaves blank space; reasons not given • Identifies broad topics without specifying the actual sub-concepts that are problematic	• Identifies only the contextual constraints • Identifies broad topics without specifying the actual sub-concepts that are problematic	• Identifies specific concepts with reasons related to specified prior knowledge of students or common misconceptions for at least one big idea	• Identifies specific concepts with reasons related to prior knowledge of specified students or common misconceptions for more than one big idea
Teaching Strategies (in, about, for)	• Provides no evidence of acknowledgement of student prior knowledge and misconceptions • Lacks aspects of curriculum saliency (e.g. corresponding subordinate concepts in a topic, sequencing for scaffolding learning, awareness of the background concepts needed before teaching the topic) • There are few opportunities for student development; Suggested activities are largely teacher centred • Justification for choice of teaching strategy not provided	• Acknowledges student misconceptions with no corresponding confrontation strategy • Lacks aspects of curriculum saliency • Uses a few T/L strategies with little variation hence limited involvement of student s as student s are given tasks that develop recall • No justification for choice of teaching strategy	• Overall, strategy workable • Considers confirmation/confrontation of student prior knowledge and/or misconceptions • Considers at least one aspect related to curriculum saliency: sequencing or what not to discuss yet or emphasis of important concepts • Provides justification for choice of teaching strategy but not necessarily aligned to EE • There is evidence of encouraged student involvement; experiments with a variety of T/L strategies hence student s given comprehension or application tasks	• Overall , excellent strategy to teach required concept • Considers confirmation/confrontation of student prior knowledge and/or common misconceptions • Considers at least two aspects related to curriculum saliency: sequencing, what not to discuss yet, emphasis of important conceptual aspects, etc. • Provides justification for choice of teaching strategy consistent with EE specific strategies (in, about, for the environment) • Highly student centred lesson; thoughtfully selects and effectively uses a variety of T/L strategies appropriate to the content and student s.

Appendix N: 3 Year JC Social Studies Textbook Extracts' Analysis

Use the following criteria to evaluate the textbooks extracts on Water resources and conservation:

0 – This element is not evident in the textbook extract being evaluated
1 – Some evidence of this element is in the textbook extract being evaluated
2 – This element is a component of the textbook extract being evaluated
3 – This element is very evident in the textbook extract being evaluated

Textbook characteristics	**Book Tittle:** *Exploring Social Studies, Form 1*, **Author/s:** Ford, R., Mlambo, A. & Mosetlhi, S. & Ndaba, V., (2009). **Publisher:** Heinemann				**Book Tittle:** *Social Studies, A fresh start Book 1* **Author/s:** Gatsha, G. & Ngongola, V., (2009) **Publisher:** *Diamond Educational Publishers*				**Book Tittle:** *Social Studies Form 1* **Author/s:** Mpitse, D.L., Rampha, L. & Tsayang, T., (2009) **Publisher:** Collegium			
Curricular saliency	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
The authors' understanding of the place of the topic in the curriculum												
Understanding of the purposes for teaching the topic												
Awareness of how topic fits into the curriculum												
Content												
The content is complete and up to date												
The content is appropriate to the level of the students												
The content is logically sequenced												

The content is free from factual and technical errors												
The material relates new material to what the student has already learnt in the past												
Explanations												
Descriptions and details are clear enough for the student s												
Representations												
Diagrams, illustrations and pictures are well presented												
Illustrations clarify what is presented in the text												
Diagrams and illustrations are appealing to the eye												
Topic specific strategies												
The methods used in extracts are consistent with the aims and objectives of EE												
Approaches are student centred												
There is scope for students to learn at different paces												
The approaches are activity based												
There are case studies provided for student s and are relevant to EE												
The extracts provided allow for whole class, small group collaboration and individualised instruction												

Assessment												
Embeds continuous assessment in student learning												
Uses varied forms of assessment (e.g. projects, essays, case studies, multiple choices etc.)												
Includes a variety of questioning techniques (e.g. fact and recall, open ended, probing and clarifying, application / transfer) beyond recitation												
Encourages students to model, represent, and reflect in written oral and pictorial forms												
Total for each column												
Grand total												
Total percentage												

Depending on the analysis above, which is your most preferred textbook and briefly sum up the reasons why? (Include the strengths and weaknesses)

Appendix O: *WSOE Rationale for lesson design template*

SECTION 1: Routine information

Form: _____ Subject: _____

Theme: _____ Duration: _____
Topic: _____
Sub – topic: _____
Sub – topic for the topic that came before: _____
Sub – topic for the topic that will follow: _____

SECTION 2: Purpose of the lesson

Key Questions (*1 -3 most important questions student s should be able to answer after this lesson)*
Skills *(What should the pupils learn how to do during the lesson?)* *During this lesson, students will learn how to ….*
Attitudes and values *(What does this lesson promote as being good or just or fair?)*

SECTION 3: Content knowledge for the lesson *(Summarise your understanding of the most important content knowledge of this lesson)*

SECTION 4: Student factors to consider in relation to topic *(student diversity, prior knowledge, subject vocabulary, examples for better understanding, evidence of understanding to be produced, misunderstandings/mistakes and ways of pre emptying student possible misunderstandings***)**

SECTION 5: Teaching and learning strategies *(most suitable strategies for this topic, what classroom tasks could deepen student understanding of topic)*

SECTION 6: Sequence of lesson steps

Aim of lesson step	Describe what will happen in each lesson step *(learning activity)*	Resources needed
1.		
2.		
3.		
Conclusion		

Appendix P: Completed teacher questionnaire

Code for Admin purposes:	

PART II: ENVIRONMENTAL ISSUES

1. Please indicate whether you disagree or agree with each of the following statements about the environment by ticking (tick✓):

	Strongly Agree	Agree	Not sure	Disagree	Strongly disagree
The earth has plenty of natural resources if we just learn how to develop them	✓				
Plants and animals have as much right as humans to exist			✓		
The balance of nature is strong enough to cope with the impacts of modern industrial nations				✓	
The earth is like a spaceship with very limited room and resources				✓	
Humans were meant to rule over the rest of nature		✓			
The balance of nature is very delicate and easily upset	✓				
The so-called ecological crisis facing humankind has been greatly exaggerated					✓
If things continue on their present course, we will soon experience a major ecological catastrophe					✓
I am very concerned about the environmental issues in my own community	✓				
I am very concerned about global environmental issues	✓				

1 (a). If you strongly disagree with any of the above statements, you may explain your position.

The global warming is now reaching a crises level as evidenced by some natural disasters (Drought, floods (Thailand) Excessive heat ~~(Botswana)~~ Bots) excessive cold in Europe. These catasphes have cost more than thousands of human life and destroyed infrastructure and displaced people. Yet industrialised countries are reluctant / ~~to~~ to refusing to abide by the / kyoto protocols.

3

PART III: *WATER MANAGEMENT IN BOTSWANA*

2. Which of the following environmental problems affect your community? Please indicate your answer with a tick (✓):

Environmental problem	
Waste disposal	✓
Water quality	
Water quantity	
Soil degradation	
Air pollution	
Alien vegetation	
Habitat destruction	
Energy	
Endangered animals and plants	

3. What are the main concerns and/or issues that your community has about their water supply and quality, if any?

There are not many issues concerning water supply and quality but the main concern especially in the low income townships drainage systems are bad with dirty water flowing in streets and exposing people to health threatening diseases.

4. Do you think that Botswana should be concerned about the availability and quality of water resources? Why or why not?

Yes Botswana should make sure there is constant availability of quality water resources. If the quality is bad it can expose people to ~~Health~~ harmful disease and in turn threaten human security and economic prosperity of the country.

4

5. What do you think are the most important threats to water resources in Botswana?

- Unreliable rainfall
- Droughts
- Pollution

6. If you were to make recommendation/s to the Government of Botswana, on ways of ensuring sustainable water quality and supply, what would you recommend?

I would recommend to govt to take advantage of perennial rivers like Okavango, Zambi, Chobe, Thamalakane and source water and make water treatment plants ~~there~~ and water storage facilities to maintain constant supply and use during times of droughts.

7. What do you think about the recycling of sewage water as an option of water management in Botswana? Explain your answer.

The technical expertise used to carry out such a project should be of an all time high standard as because it involves high level of risks that may threaten the health security of the human and other life species

PART III: TEACHING OF WATER RESOURCES AND CONSERVATION

8. Why do we teach children about the environment? Please indicate your answer with a tick (✓):

Children need to:	**Very Important**	**Somewhat important**	**Not important**
Understand how people and their environment are connected	✓		
Understand different views on environmental issues	✓		
Gain basic knowledge of environmental concepts		✓	
Understand natural processes		✓	
Develop awareness of important environmental issues	✓		
Develop an appreciation of the natural environment	✓		
Be aware of their responsibility for looking after the environment	✓		
Learn what individuals can do to make a difference	✓		
Understand the impact of one's choices and decisions on the environment		✓	
Behave in an environmentally responsible manner	✓		
Take action to improve environmental quality	✓		
Become aware of one's responsibility to the earth	✓		
Improve communication skills	✓		
Improve critical thinking skills	✓		✓
Improve self esteem			✓
Improve problem solving skills	✓		

9. What does it take to be an effective environmental education teacher?

A thorough academic and ~~non~~ indegenious knowledge about environmental issues eg conservation preservation etc., and a deep commitment to ~~to~~ what the subject want to achieve (aims & objectives)

10. What do learners need to know before they can understand the management and conservation of water resources?

They must understand about the challenges, opportunities and threats to their own water resources from their homes, schools and communities etc

11. Why is it important for students to learn about the management and conservation of water resources?

So that they can become effective movers for the change of negative mindsets that water Management / conservation is not a serious issue. They are also the future generation.

12. What are with the challenges of teaching about the management and conservation of water resources?

The negative mindset prevalent is from their students home environment, lack of education from home etc.

13. What common misunderstandings do you think children might have about water resources and their management?

The misconception that water is not a scarce resource and is readily available as there are annual rainfall

Thank you for your cooperation. It is highly appreciated. Le kamoso!!

Appendix Q: Completed Beliefs tool

Code for Admin purposes:

BELIEFS ABOUT TEACHING

1. What made you choose teaching as a career?

Teaching is the mother of all professions. We have different professions which are all products of teaching, so I wanted to contribute to different students in their career path, make some influences in the outcome of students career life.

2. What do you love about the job?

Helps me interact with different people of different characters hence I learn from everyone I meet in the teaching learning process.

3. What do you find challenging?

Having to teach students from different social, cultural and religious background who bring to class different opinions, level of understanding and beliefs which I have to infuse in delivering the content for better understanding of concepts by all students.

4. What would you say are the most important things that make someone an effective teacher?

An effective teacher should consider that students are not passive but active learners who bring to class some background knowledge. S/he should also understand and accept the different abilities of students and modify teaching methods to cater for all students.

5. How do you maximize student learning in your classroom?

* Encourage all students to participate in classroom discussions.
* Every student is to participate in class activities e.g presentations.
* Students are applauded for contemplating or answering questions in class.

6. A simile describes the characteristics of one thing with another. Think of a job that has something in common with being a teacher and explain your analogy?

Being a teacher is like being a parent because if you are a teacher students learn from you. Teachers attitudes and beliefs can reflect on students s/he teaches, just like student on first days at school still carry/uphold to the principles and behavior they have learnt from their parents. Teachers responsibility is not only to teach content of the subject but also contribute in building a good character of the student, the job parent do.

7. Here is a list of statements about effective teachers. Decide if you agree, partially agree or disagree. If you don't agree, state your reason(s) in the space below each statement.

An effective teacher...	Agree	Partially	Disagree
I. Keeps learners quiet and orderly during a lesson.			✓
II. Tells learners the information they need to know.			✓
III. Keeps the learners doing their work until the end of the period.			✓
IV. Thoroughly understands the topic of the lesson.		✓	
V. Has everything organized and doesn't waste time during the lessons	✓		
VI. Asks learners if they all understand, after the explanations.	✓		
VII. Marks their class work and checks that learners get the right answers.	✓		
VIII. Reflects on how each lesson went to learn from experience	✓		
IX. Delivers each lesson within the allocated time period		✓	
X. Knows how learners will probably understand and misunderstand a	✓		
XI. Has a friendly and warm relationship with learners	✓		
XII. Prepares for lessons by memorizing the facts that learners need to know			✓
XIII. Has a clear idea of the purpose of each lesson and what learners will do	✓		
XIV. Connects the lesson to what the learners already know	✓		

Now take the comments that you agreed with. Rank their numbers in order of importance.

Most important → Least important

X I	V III	X III	X IV	X	V	V II	V I						

8. How do you know when your students understand?

After every lesson or before the end of any lesson, probing questions that address key points of the topic are asked and students response will determine their understanding and or a homework will be given, answers will also reflect students understanding of the concepts.

9. How do your students learn best?

Students learn best if they are allowed to participate in class instead of being demoted to passive learners (listners while the teacher preaches the whole content.

Thank you for your participation!!!

Appendix R: Boitshepo's CoRe

Boitshepo's CoRe				
YEAR LEVEL FOR WHICH THIS CORE IS DESIGNED Form 1 (equivalent Grade 8	IMPORTANT IDEAS / CONCEPTS			
	Big idea A **Many human activities depend on access to water**	**Big idea B** **Although water is a renewable resource, the amount of usable water available is limited by how much can be stored**	**Big idea C** **Water can be transported from one region to another**	**Big idea D** **Water pollution can decrease its usability**
What do you intend the **students** to learn about this idea?	• Water is needed for human activities such as domestic, industrial and agricultural purposes • There is plenty of surface water in some parts of Ngamiland, however the water is not safe for human consumption, leading to severe shortage of quality water in the area • Boreholes were dug along the river and when it gets flooded, they submerge leading to severe shortage of water	• Types of water sources • Available water sources in the area and human activities • Condition and challenges of water sources (such as flooding of boreholes • Damming of natural sources (e.g. Okavango river) • Challenges of damming (blockage of water flow to rivers and dams) • Direction of the flow of surface water and areas where dams are constructed • Water conservation strategies (e.g. recycling of waste water in major settlements where population growth is high, rainwater harvesting) • Available water conservation areas and their uses • Impact of water conservation strategies on water resource management • Construction of water purification plants • harvest rain water by constructing more dams in areas where there are seasonal rivers • Sustainable use • Water to be recycled in all the areas in Botswana more especially major villages, towns and cities where the population is increasing • Dam rivers in areas where necessary, Construction of water purification plants in big villages, Water levy be introduced and		• Water pollution is unsustainable (leads to severe shortage of water) • Effects of dumping of industrial waste in water channels • Types of Pollution – Underground water more especially in villages where pit latrines are common - Industrial waste – People usually dump industrial waste in channels used by water during rainy seasons. This block the flow of water to dams and rivers • Construction of water purification plants

		every yard connected to water, Harvest rainwater • I will recommend recycling of sewage water. This is because water sources are drying up and more water is needed for domestic, industrial, and agricultural purposes.		
Why is it important for students to know this?	• To identify water sources and human activities	• To be able to conserve water where possible • To identify areas of management • Value water as an important and scarce resource • Promote sustainable use of water and attitudinal change	• Water flows from high land to low land e.g. for construction of dams	• Pollution affects water resources negatively (surface and underground)
What do learners need to know before they can understand this topic	• What is management and conservation of the environment • Which strategies are being used to conserve water and the impact of these strategies have on water resource management • Water sources			
What else **you** know about this idea (that you do not intend student to know yet)	- Apart from domestic , industries and agricultural activities water can be used for economic purposes	• Underground water can also be stored or conserved	• Not only surface water flows/runs downhill.	• Stagnant water can also be hazardous i.e. can cause diseases
Difficulties / Limitations connected with teaching of this idea	•Indigenous knowledge on human activities that depend on water	• Indigenous knowledge on water conservation methods	• Indigenous knowledge on the flow of rivers • Perennial and seasonal	
Knowledge about students' thinking that influences teaching of this idea	• Water is not scarce (especially for those students who come from the wetland areas with plenty surface water • there is plenty of water in dams, rivers and boreholes	• Attitudes that water is plenty as long as there will be other rainy seasons -		• Attitudes of throwing things in water • Students are familiar with pollution and how it can affect life
Other factors that influence your teaching of this idea	• Lack of resources			
Teaching procedures (and particular reasons for using these to engage the students)	• Group discussion and class discussion • So that students can come up with different ideas	- Class discussion - students to brainstorm water conservation strategies	- Class discussion and group discussions, pair work	- Show posters of polluted water sources - Class discussion and group discussions
Specific ways of ascertaining students understanding or confusion around this area (include likely range of responses)	- Presentations in class and discussions to clarify confusions	- Cross pollination of ideas through discussions in class	- Class exercise	- Class exercise

Appendix S: Felicia's CoRe

Felicia's CoRe				
YEAR LEVEL FOR WHICH THIS CORE IS DESIGNED **Form 1 (equivalent Grade 8)**	**IMPORTANT IDEAS / CONCEPTS**			
	Big idea A **Many human activities depend on access to water**	**Big idea B** **Although water is a renewable resource, the amount of usable water available is limited by how much can be stored**	**Big idea C** **Water can be transported from one region to another**	**Big idea D** **Water pollution can decrease its usability**
What do you intend the **students** to learn about this idea?	- Uses of water (Irrigation, Wildlife and domestic animals) - Importance of water in our daily lives - Challenges with water sources and supply (e.g. inadequacy, salinity in some water sources interrupted water supply, unreliable rainfall) - Not all communities have enough water supply e.g. Serowe, Maun - - Most of the water meant for human consumption is salty e.g. Serule, Kgalagadi areas - interruptions of water supply every now and then	- Name Sources of water and availability - Rainfall patterns contribute to availability of water - Ways of conserving water (reduce, reuse, recycle; strict water charges; enacting laws/policies; use of water saving devices, construction of dams; public education and awareness, purify sewage water) - Challenges posed by high temperatures (high evaporation rates) - Topography encourage the building of dams		- Ways of polluting water (e.g. flooding) - Strategies to combat pollution (re-enact strict laws on pollution) - Water needs to be treated so that it is used by humans -
Why is it important for students to know this?	- To appreciate the need to conserve water - Understand that we all depend and need water for different aspects of our lives (domestic vs. business) and that the absence of water affects us in different ways and magnitude	- To understand and appreciate the changing rainfall patterns (unreliable and variable rainfall) so that we can … - Fully Practice ways to conserve water in Botswana - Make observations on water usage - Assess the strategies used to conserve water - Promote positive attitude towards handling water (be water wise) - Value water as an important and scarce resource	- People look up to rain to bring water	- To avoid polluting water
What do learners need to know before they can understand this topic	- Importance of water in daily lives - Water is a scarce resource - sources of water - - The availability of water resources			

What else **you** know about this idea (that you do not intend student to know yet)		- Grey water harvesting - Water lost through evaporation at dams	- What would happen if areas with water could not share with others (death due to thirst as a result of unfavourable geographic allocations, civil and regional wars as a result of unfair water practices like river blocking, water harvesting	- Polluted water is harmful to both people and other living things
Difficulties / Limitations connected with teaching of this idea			- Limited knowledge of topography	
Knowledge about students' thinking that influences teaching of this idea	- Water is plentiful so there should be no alarm - Water is brought by rainfall so there is yet another rainy season	-Students see the task of Government building of dams so that they can continue to have water flowing in their taps -They don't feel they are accountable for water wasted in their homes, community standpipes and at school. -	- some students believe that water comes cheaply	
Other factors that influence your teaching of this idea	- Curriculum fully packed - Time table constraints - Availability of resources - Numbers in class	- Curriculum fully packed - time table constraints - Availability of resources -- Numbers in class	- Curriculum fully packed -Time table constraints - Availability of resources - Numbers in class	- Curriculum fully packed - Time table constraints - Availability of resources - Numbers in class
Teaching procedures (and particular reasons for using these to engage the students)	- Class discussions	- Group discussions – provide learners with challenging questions in their groups to encourage them to work as teams to fight the environmental issues facing them, share ideas. This allows for development of problem solving and participation - Video clip - Mini research project - Reading	- Lecture	- Panel discussions on challenging questions
Specific ways of ascertaining students understanding or confusion around this area	- Class exercise - Quizzes	- Research - Oral exercise - Quiz	- Report writing	- formation of advisory club on environmental issues - observing for sign of behavioural change and participation in water conservation practices

Appendix T: Irene's Core

Irene's CoRe				
YEAR LEVEL FOR WHICH THIS CORE IS DESIGNED **Form 1 (equivalent Grade 8)**	**IMPORTANT IDEAS / CONCEPTS**			
	Big idea A **Many human activities depend on access to water**	**Big idea B** **Although water is a renewable resource, the amount of usable water available is limited by how much can be stored**	**Big idea C** **Water can be transported from one region to another**	**Big idea D** **Water pollution can decrease its usability**
What do you intend the **students** to learn about this idea?	- Uses of water - Quality of water - Quantity of water - - limited surface water a lot of areas experience water shortage especially in the rural areas - Areas with water are often supplied with saline or polluted water - Tutume village has been having a water shortage problem for more than a decade and a half now resulting in frequent water cuts and that meaning that people have no choice but to resort to drinking water from the river, the water provided is also salty - Water shortage is due to minimal supply and damage to engines	- Sources of water and availability of water in the water sources - Ways of conserving water (Build more dams, Subsidies on water storage tanks, water harvesting, water conservation education) - Factors affecting water conservation - water evaporation - Damming and its challenges -	- Run off - Carrier water projects	- Ways of polluting water (Pollution due to pit latrines) - underground water pollution - Identify polluted sources of water - Effects of polluted water on people and animals - Investigate major sources of pollution - Water is the key to a nation's health. If it is not available, people end up drinking contaminated water and falling sick., putting more strain on health resources
What do learners need to know before they can understand this topic	- Sources of water, their capacity and its importance			
Why is it important for students to know this?	- To appreciate and Understand that water is an important and scarce resource - To sustain water to benefit us longer	- To know the capacity and the amount of water in the dams of available water resources (against supply area and population) - To develop skills in conservation and management as well as appreciate water sources - Assess factors affecting water conservation - Develop a sense of responsibility	- Appreciate water by various means - Know that damming is the result of water from other places - That other places have enough water - Expenses incurred in transporting water from one region to another e.g. North South water project	- To avoid water pollution - Know various ways in which water can be polluted - To develop skills in management as well as appreciate water sources

		on issues affecting water and willingness to conserve it. - Change attitudes - Raise awareness on water sustainability - Understand that water is an important and scarce resource - Understand that Climate change has effects on availability of usable water		
What else **<u>you</u>** know about this idea (that you do not intend student to know yet)		- That droughts also affects available usable water - That there is a possibility of future water supply from new dams under construction	- That certain areas with dams experience water shortage due to carrier water projects - That some of our water is imported	- That usable water is also limited by contamination form flooded boreholes - That certain industrialised countries dump toxic waste in seas and shores killing Marine life - Air pollution as cause of Acid rain that pollutes water too
Difficulties / Limitations connected with teaching of this idea	- Students may get lost during discussions of human activities that learners are not familiar with - Students may take availability of water for granted if they live in an area of good water supply hence difficult to be convinced that water is a scarce resource - You teach about proper management on the other hand, pipe bursts especially in large rural areas like Tutume could go for years without being attended by the very water department that is supposed to be more responsible - In some schools, there's poor water management especially where you find individual students washing own dishes under taps	- Students may fail to understand why enough water cannot be stored or why there can't be enough storage resources	- Some learners are not familiar such activities only know of water from local rivers, dams, boreholes	
Knowledge about students' thinking that influences teaching of this idea	- They know that domestic water is essential for use - Myths such as: * Water used for bathing cannot be used for watering plants	- Learners do not seem to understand that usage of water affects the capacity at source - Traditional beliefs and myths that learners bring to class (it will	- Think that they can go uphill or upstream to seek clean water not realising that one's upstream is another's downstream	- Think that all water from taps is clean and cannot be contaminated - They indiscriminately throw litter in their rivers without

	* For many areas water sources are dams and learners tend to believe that water coming from taps cannot run out *water from the tap is clean and cannot be contaminated Water from the dams cannot dry out	always rain as long as the god's have been appeased –rainmaking and praying for rain)	- Traditional beliefs and myths that learners bring to class (it will always rain as long as the god's have been appeased –rainmaking and praying for rain)	realising that although they don't drink the water from the rivers, throwing litter in the rivers ultimately affects the water in the dams. The water that is then purified and supplied to the taps. Thus they are not able to establish the link between the water they drink and that from the rivers they pollute.
Other factors that influence your teaching of this idea	- Curriculum constraints whereby teacher has to follow within the limitations of the syllabus	- Lack of responsiveness of water department in reacting to water pipe bursts undermine the emphasis by the teacher that water is a scarce resource - Poor management of water in some schools	- Curriculum constraints whereby teacher has to follow within the limitations of the syllabus	
Teaching procedures (and particular reasons for using these to engage the students)	- Brainstorming 10 minutes to solicit wide and quality responses - Group research work and presentations on the uses of water and its quality – students do research on the topic and then in the following lesson their share their findings with their group members, consolidate and then present to the whole class	- Lecture / Discussion guided by teacher to enhance the direction of the objective - Group discussion – for students to compare their findings - presentation	- Class discussion after a passage reading. To engage them fully and clear misunderstanding - Show video on water transportation - Invite guest from water department to explain	- A hands on Mini research to fully involve learners and ensure they link with the environment and expose the malpractices and water mismanagement in the school a hands on activity - Identify a problem in school and address it even if they involve water authorities in their community - Write reflection papers or mini reports on the issues addressed by the guest speaker from the department of water
Specific ways of ascertaining students understanding or confusion around this area (include likely range of responses)	- Ask oral questions later followed by home work on short exercise - Completing a puzzle - Role play	- Oral questioning - Written summary by students	- Oral questioning - Written summary by students	- Video show - Passage reading - Charts - Listening comprehension and quiz

Appendix U: Kagiso's CoRe

Kagiso's CoRe				
YEAR LEVEL FOR WHICH THIS CORE IS DESIGNED **Form 1 (equivalent Grade 8)**	**IMPORTANT IDEAS / CONCEPTS**			
	Big idea A **Many human activities depend on access to water**	**Big idea B** **Although water is a renewable resource, the amount of usable water available is limited by how much can be stored**	**Big idea C** **Water can be transported from one region to another**	**Big idea D** **Water pollution can decrease its usability**
What do you intend the **students** to learn about this idea?	• The importance of water sources on humanity • The main water sources of water resources • critical uses of water(activities) that can be affected by shortage of water in their villages • We are an arid country with very limited water sources. It is very expensive to secure and supply portable water • The water sources are limited and always experience water shortages, particularly for livestock	• The importance of water resources conservation • Ways of conserving water resources - water conservation practices in the students' communities (e.g. water harvesting) - putting up regulations to enforce both industrial and domestic conservation of water resources. - recycling waste water (The amount of water lost on each day as waste water if re - harvested can ensure sufficient supply of water.)	• Challenges associated with water distribution/ provision of portable water	• - practices leading to damaging of water (Excessive generation of waste and poor waste management has created recipe for water pollution including continued use of pit latrines by the majority) • Dangers of poor waste disposal on water safety (Pollution: our land is so polluted with all kinds of waste that our rivers can't escape the dirt. Industrial waste is also poorly handled. The continued use of pit latrines also threatens underground water sources) • Ways of reducing pollution (prohibiting use of pit latrines, ensuring usage of sewage systems, employing improved waste management strategies in both industrial and domestic areas, privatisation of waste management)
Why is it important for students to know this?	•Know where water is sources so that they understand their relationship with the water resources • Know that water is an important and scarce resource, without it people cannot survive •So that they understand the	• To realise the degree of shortage of portable water in Botswana • So that they realise the importance of conserving water as well as appreciate conservation practices put in place(if they understand importance of water conservation, then they will practice it)	• So as to appreciate the challenges faced in water distribution and reticulation • To develop knowledge and skills on water resource conservation	• To understand that water is easily contaminated/destroyed and can be dangerous for human consumption • To understand the danger of poor waste disposal on water safety • To understand that polluted water reduces its usage and is dangerous to humanity

	importance of using water conservatively •So that they understand the consequences of their actions on water wastage(that they are directly affected by results of water wastage)	• To acquire knowledge and skills on water resource management • Assess water conservation practices (effectiveness) • Develop a sense of accountability and willingness to participate in water conservation •		• To empower students with knowledge and skills to deal with water pollution • To understand the costs of purifying water •
What do learners need to know before they can understand this topic	• Need to understand the consequences of their actions on water wastage. • Knowledge of where water is sourced and that which is involved to ultimately get clean water piped into their compounds • They should understand their relationship with water resources - how water resources are of importance			
What else **you** know about this idea (that you do not intend student to know yet)	• That grey water can be recycled and be used to improve water quantity	• Government plans to create a dams network system that will eventually see most major settlements supplied with piped water	• That the current dams network system in Botswana is aimed at improving portable water distribution	• That water recycling process can make damaged water to be re be reused
Difficulties / Limitations connected with teaching of this idea	• The majority of pupils nowadays have never had the experience of shortage of water and only know piped water, so it is a challenge to convince them that water is a scarce resource	• Teaching children coming from backgrounds /families that have very little concern about water conservation, this attitude is difficult to deal with • Most students find water in their pipes and easily accessible so they have no idea of the costs involved. They also don't understand the difficulty posed by our climate conditions.	• Teaching children coming from backgrounds /families that have very little concern about water conservation, this attitude is difficult to deal with	• In areas with less generation of waste, it may not be easy convincing pupils about contamination • How to convince pupils that pit latrines leads to contamination of water
Knowledge about students' thinking that influences teaching of this idea	• Students tend to think there is plenty of water, they don't believe that water is a scarce resource	• Their lack of knowledge and understanding of shortage of water particularly in rural areas • Learners from different cultural backgrounds and learning disabilities. Students in rural areas will easily understand the problem of shortage of portable water as its common and regular	• That they take the cost of water transportation as of no real concern	• The fact that students take much of the kind of waste they generate themselves light as a source of water pollution • The students don't see the link between water and waste

		unlike students in towns with 'ever flowing' tap water		
Other factors that influence your teaching of this idea	• Concerns about the costs of purifying water	• Shortage of water in many parts of Botswana	• The growing demand for portable water supply • The continuing shortage of portable water resources	• Excessive waste generation and poor waste management are common in our community
Teaching procedures (and particular reasons for using these to engage the students)	• Using group work strategies and video watching - To help pupils share ideas and show real life situations to make them understand • Mini project related to the big idea so that they can be able to produce something that shows there is acquisition and comprehension	• Small group discussions - To enable effective participation • Investigate factors affecting water quantity and quality • Mini project related to the big idea so that they can be able to produce something that shows there is acquisition and comprehension	• Site visits to place – water pumping station and areas of severe water wastage • Group discussion • Mini project related to the big idea so that they can be able to produce something that shows there is acquisition and comprehension	• Investigation – exploration of facts and information finding tasks. This enhances student knowledge and insight on the problem, improved attitudes, more practical as well as sound decision making • Project / campaigns • Group discussion • Mini project related to the big idea so that they can be able to produce something that shows there is acquisition and comprehension
Specific ways of ascertaining students understanding or confusion around this area (include likely range of responses)	• Use of class quizzes and class exercises	• Class exercise and quizzes	• Evaluation exercise • Quizzes and assignments	• Assignments and class exercises

Appendix V: Naledi's CoRe

Naledi's CoRe				
YEAR LEVEL FOR WHICH THIS CORE IS DESIGNED **Form 1 (equivalent Grade 8)**	**IMPORTANT IDEAS / CONCEPTS**			
	Big idea A **Many human activities depend on access to water**	**Big idea B** **Although water is a renewable resource, the amount of usable water available is limited by how much can be stored**	**Big idea C** **Water runs downhill**	**Big idea D** **Water pollution can decrease its usability**
What do you intend the **students** to learn about this idea?	-Uses of water – human activities (Domestic uses, Industrial uses) -Sources of waterBotswana is a semi-arid area, therefore has less rainfall which is also unreliable. Botswana has less surface water because of few rivers so it relies mostly on underground water which can be affected by less rainfall -Salinity of water - water shortage Quality of water –Quantity of water	- Sources of water in Botswana - Factors affecting water resources (policy issues that do not adequately address sustainability)) - environmental issues and problems affecting water supply - Water conservation * water conservation strategies – (water restrictions/tariffs, reuse, reduce, recycle, water harvesting, educational awareness for attitudinal change, non-privatisation of water supply, strengthening of existing water monitoring systems) - Climatic change may result in drying up of rivers and reduce the level of underground water- recycling waste water	- Water cycle - Contamination of water from one area to another	- Water pollutants (Pollution of water bodies by industrial waste - Effects of high population on water resources • Disposing of sewage water • Urbanisation and pressure on waste water • Industrial activities that affect/pollute water • Waste disposal and pollution of water bodies - The quality of water should also be a concern because underground water can be easily polluted by lifestyle such as building of pit latrines
Why is it important for students to know this?	- Promote awareness and promote understanding which will hopefully promote positive attitude towards the environment - Understand the importance of water to livelihood and promote Positive mind-set on water usage - Climatic factors affecting availability of water - For attitudinal change and reflection on their actions	- To educate on water conservation - Take a deliberate action towards water conservation - To connect to the environment in a positive way - To promote awareness and promote conservation of water as a limited resource -	- Reflect on their activities that affect the safety and supply of water - Reflect on one's activity on water can affect the other person -	- To promote attitudinal change on water usage - Engage learners in educating the community - Make learners custodians of a safer environment - Value and appreciate water as an important resource - Understand and appreciate their environment

what learners need to know before they can understand this topic	They need to know the sources of water resources in Botswana and the factors affecting water resources Learners need to know about the importance of water They need to know the sources of water They need to know the factors affecting water resources			
What else **you** know about this idea (that you do not intend student to know yet)	Effects on urbanisation and industrialisation on supply of water ome research that is on-going which may mislead learners	- Some research that is on-going which may mislead learners - Issues of climatic change and response from developed nations on climatic change	- Some research that is on-going which may mislead learners - Global issues	- Pollution of water by mercury that escapes from bulbs used in homes Global issues and debates on conservation
Difficulties / Limitations connected with teaching of this idea	- Information may seem irrelevant to learners who come from places with plenty of water thus the diversity of learners may send different messages to learners - Curriculum design - which promotes objectivity	- Language barrier may limit students understanding of main concepts especially those who use English as third language - Regional variation may also limit knowledge Time table constraints	- Proximity to areas used as examples in the lesson may make the information far-fetched for some learners and thus may not make sense Curriculum	- Some learners may have been exposed to unsafe water for as long as they have lived therefore may not see why this has suddenly become a problem - Resources
Knowledge about students' thinking that influences teaching of this idea	- Their values and beliefs may limit / influences the understanding of the concept (e.g. practices such as praying for rain and rainmaking. students believe that bad spells are responsible for the absence of rain and that performing certain traditional rituals such as hunting for certain birds and their eggs as well as removing certain artefacts in shrines will restore rain. Daily uses of water • The thinking that water is renewable. They think that no matter how much they use water it can always be replaced • They also think that since they pay for water why should they be concerned about how much they use	- They know that water is an essential resource to people (especially some learners come from rural areas where water is scarce and sometimes they travel long distances to get it)	- They think and believe that water is from God	- Learners know the importance of water from their daily usage - - some learners have beliefs connected to water usage and supply
Other factors that influence your teaching of this idea	- Political framework - Government policy on usage of water - How much the teacher know about the concept - traditional knowledge and methodologies used by teacher does not promote diversity in dealing with environmental issues - Resource constraints	- Political framework - Lack of motivation by the employer - Interest of the teacher in the subject - Number of students in class - traditional knowledge and methodologies used by teacher does not promote diversity in dealing with environmental	- Lack of knowledge of some concept - Support from school management to do field work - traditional knowledge and methodologies used by teacher does not promote	- Lack of support from the management to do projects Availability of finances to carry out some projects

	- Curriculum design	issues -	diversity in dealing with environmental issues	
Teaching procedures (and particular reasons for using these to engage the students)	- Lecture – to explain the objective of the lesson instructions - Group work	– to promote awareness and knowledge - - Engage learners in mini projects aimed at conserving water resources (students can make channels from dripping taps to trees or from run-off water to gardens)	- Group discussion Learner interactions – so that they share ideas	- Class debates to promote attitudinal change - Individual work to evaluate understanding - Lecture method – to explain instructions to the learner - Group discussion and presentation
Specific ways of ascertaining students understanding or confusion around this area (include likely range of responses)	- Class exercise - Quiz	- Class exercise - Quiz	- Class exercise	- Class exercise to evaluate learners understanding Oral questions and answer